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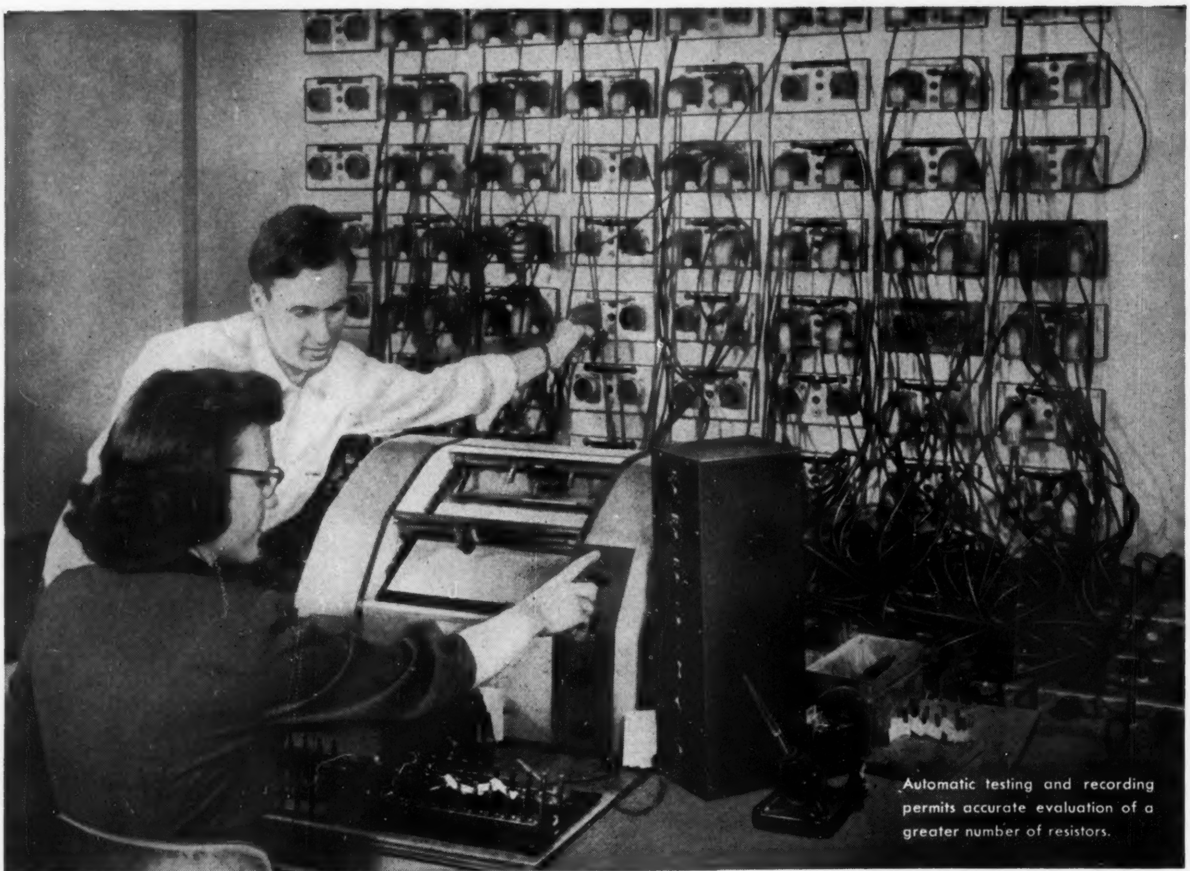

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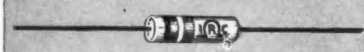

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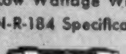

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APRIL, 1955 VOLME 20 NO. 7

COVER—Ithaca Falls from Fall Creek Bridge.

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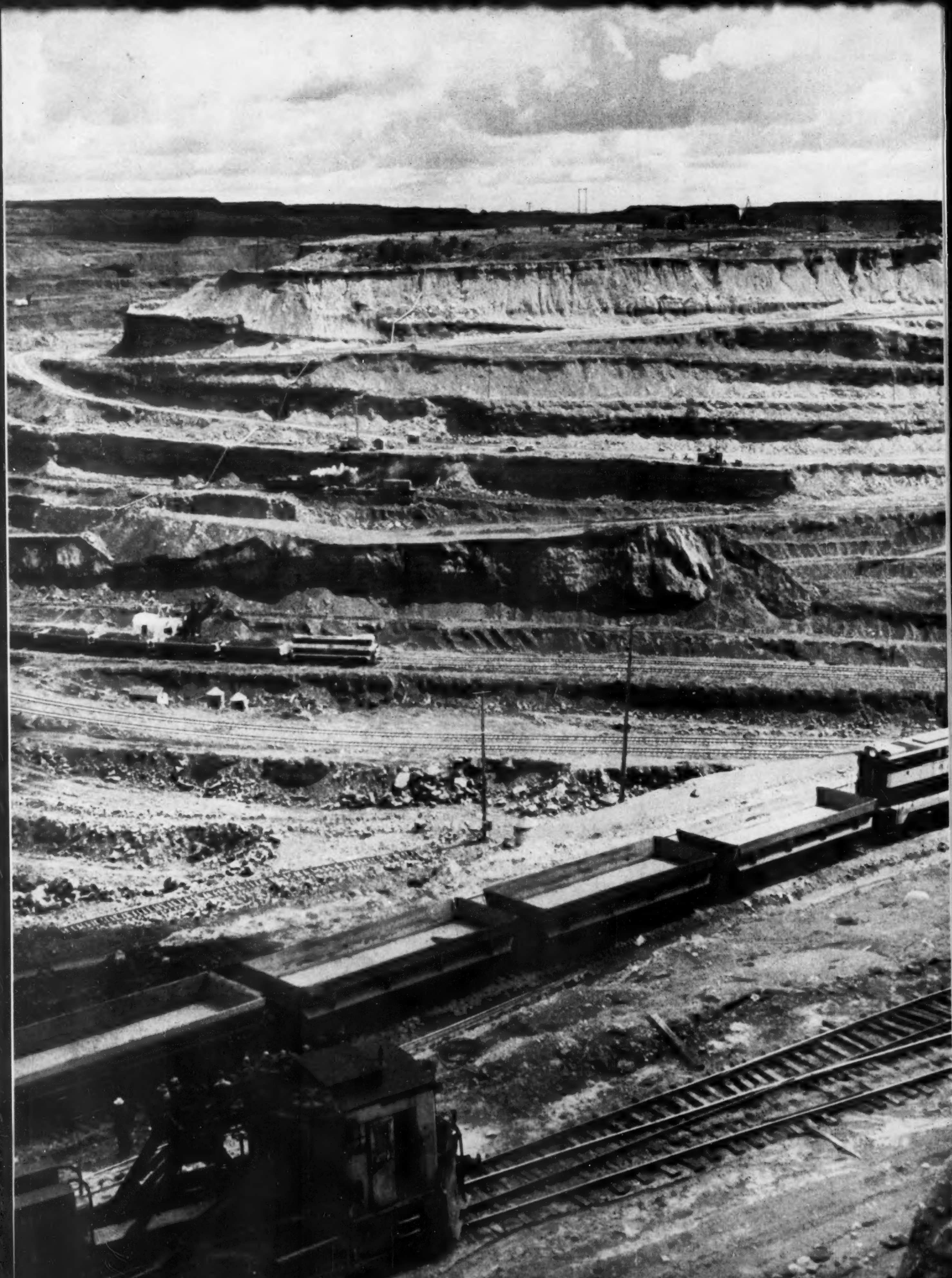
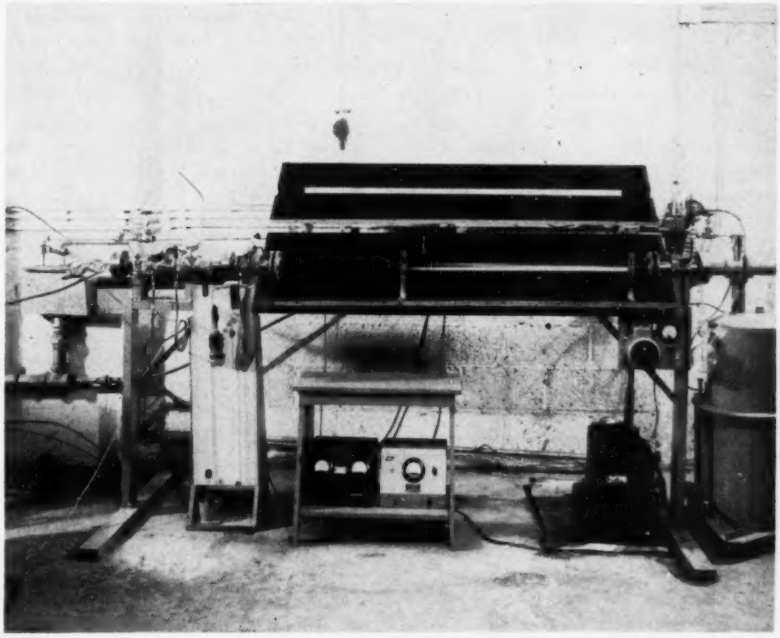


Very High Temperatures

(Reprinted from Scientific American)

by PROF. ARTHUR KANTROWITZ



—*Paul Weller*

Cornell University shock tube produces high temperatures by means of shock waves. Hydrogen in a short section at the left end of the tube is seperated from the rarefied argon filled center section by a copper diaphragm. When the hydrogen is exploded by a spark plug, the diaphragm bursts and a shock wave travels through the argon, becoming luminous at sufficient strengths.

Beyond the frontier of high temperature where the practical chemists and engineers work lies a realm of very high temperature which exists on earth only in the laboratory. It is the region from 4,000 degrees centigrade to 25,000 degrees or more. No earthly matter could long contain or survive such heat, but it is a comparatively simple feat to generate it momentarily for studies of its effects. At present these studies are of no great interest to anyone except astronomers and aeronautical (or astronautical) engineers. They will become increasingly important, however, both in basic investigation and in practical affairs.

At the temperatures we are considering there are no solids or liquids—all matter is gaseous, frequently in violent motion. In other words, we are dealing with the dynamics of high-energy gases. In recent years a remarkable convenient device for such work has been developed. It is the shock tube, which can generate extremely violent shock waves. Whenever a gas is compressed suddenly, it gains some heat. When the pressure is applied with extreme speed in a shock wave, such as is generated in an explosion or by an airplane flying faster than the speed of sound, a far higher proportion of the mechanical energy—in fact, most of it—is converted into heat. At Mach 4 (four times the speed of sound) the nose of a supersonic airplane would be heated to nearly 1,000 degrees centigrade if it were not cooled. At Mach 10 a shock wave will heat air to about 3,000 degrees; at Mach 20, to 6,000 degrees. Temperatures of this order have been achieved and investigated for some time by means of the electric arc. This article is concerned with recent studies in the shock tube.

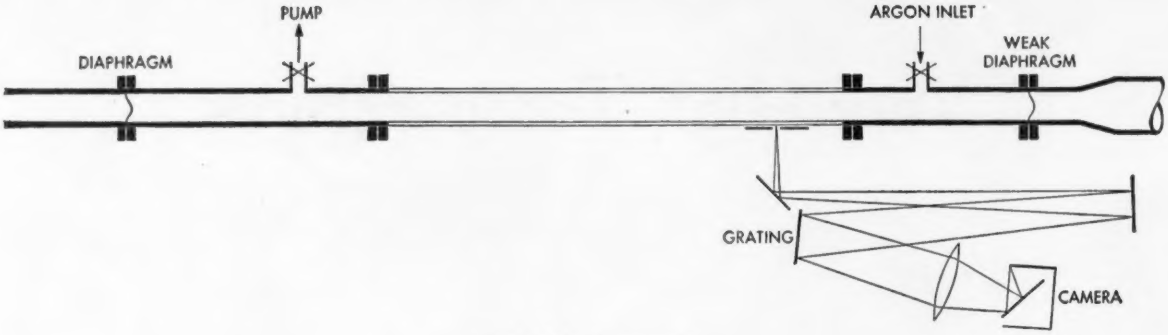
The shock tube is a simple device for producing rapid pressure jumps. It is a gas-filled tube divided into two sections by a diaphragm. The pressure is pumped up in one compartment until it suddenly ruptures the diaphragm and propagates a shock wave in the other. With hydrogen as the driver gas, and the addition of a little oxygen to explode it, shock waves with speeds up to Mach 20 can be produced. Another type of shock tube, in which low-pressure gas is suddenly heated by an electric spark, has achieved shock waves as fast as Mach 34.

High-energy gas dynamics has been studied with the shock tube by groups working with Otto Laporte at the University of Michigan, Edwin L. Resler at the University of Maryland, Richard G. Fowler at the University of Oklahoma and the author at Cornell University. These investigations have developed new information about (1) the chemical aspect and (2) the electrical and magnetic behavior of gases at very high temperatures.

At 20,000 degrees or more the molecules of a gas are completely dissociated into atoms, which usually are stripped of one or more electrons, *i.e.*, ionized. The principal object of the research on the

General view of mining operations in the Hull-Rust-Mahoning iron ore mine —the world's largest, at Hibbing, Minnesota.—See pg. 18

—*U. S. Steel Corp.*



Shock Tube Components.

"chemistry" of these high-energy gases is to determine how rapidly the predicted changes in the composition of the gas will take place in practice.

One substance that has been rather carefully studied is the rare gas argon. At 20,000 degrees C. half of the atoms of this gas will have lost an electron. Harry Petschek and Shao-chi Lin at Cornell have used the shock tube to elucidate some details which may suggest how this process goes. When argon gas is heated by a shock wave in a glass tube, there is usually no immediate visible effect. But after an "incubation time" of from one millionth to 100 millionths of a second, depending on the temperature, the gas suddenly glows brilliantly. It seems clear that the luminosity is due to a large collection of electrons which have been "bred" by some such process as the following. There must be a few free electrons in the gas to begin with; just how they are released is unknown (perhaps by ultraviolet light). When the shock wave comes, these electrons are accelerated by collisions with the hot argon atoms. The electrons are so much less massive than the atoms, however, that they gain only a little energy from each collision. At a temperature of 23,000 degrees it takes about two million such collisions for an electron to acquire enough speed to knock another electron out of an atom when it hits one. But at this temperature (and under a pressure of five atmospheres in the shock tube) an electron will undergo that many collisions in about a millionth of a second. So at the end of a millionth of a second the number of electrons in the tube will have doubled; a millionth of a second later they will have quadrupled. At 23,000 degrees the incubation time before the glow appears is four millionths of a second, which means that the electrons have had time to multiply nearly twentyfold, and the light they produce has increased 400-fold.

Solar prominence that occurred June 4, 1956, resembled a terrestrial explosion led by a thin shock front. Some portions of the prominence suggest gases flowing along magnetic lines of force.

—Harvard University High Altitude Laboratory

When a gas is heated by an electric arc, the electric field, rather than collisions with high-speed atoms, accelerates the electrons to the energy that enables them to dislodge electrons from atoms and multiply. It was known that in an electric arc the electrons quickly reach a "thermal equilibrium," in which the number of electrons produced is matched by the number recaptured by ions. Thermal equilibrium also is reached in a shock tube, it was found. This was proved by a study of the spectrum of the luminous flash at the end of the incubation period. The number of electrons in the gas could be measured by a shift toward the red and a broadening of the lines in the argon spectrum. This measurement disclosed that the electron density in the tube, as in an electric arc, leveled off momentarily at an equilibrium value. There also appeared a strong continuous radiation throughout the visible spectrum which is characteristic of highly ionized gases.

All this has some bearing on the problem of supersonic flight. If we are to design airplanes to fly at a speed such as Mach 10 without burning up, we must thoroughly understand the transfer of heat in air at high temperatures. This in

(Continued on page 38)

Telephone Carrier Systems

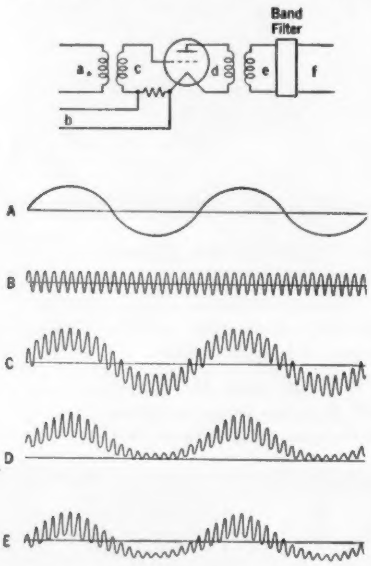
by JOHN F. AHEARNE, EP '57

In 1876 Alexander G. Bell laid the foundation of the immense organization which bears his name—the Bell Telephone System. His invention of the telephone opened a new era in communications. Since this initial invention, thousands of ideas have been developed into improved mechanisms and methods, thereby advancing telephony. With the advent of radio, the inventive ability and inquiring minds of many more scientists and engineers were applied to the solution of communication problems.

One product of the ensuing work was the carrier principle of transmitting a signal. Since a purpose of a telephone system is to transmit a voice signal, the carrier principle was applied to telephony and has proved to be a major step in the never-ending progress of our communications system.

In this method of communication, the signal voltage is impressed upon a relatively high frequency wave, the latter being named the carrier wave. This enables a low frequency signal to be transmitted by electrical waves of frequencies comparable to that of the carrier wave. The principle advantage of this method is that several signals of similar frequency can be transmitted over the same wires without mutual interference by using different carrier frequencies for each signal.

Figure 1. Currents in Modulator Circuit.



Modulation is the process of impressing the signal on a carrier. Of the methods of modulation, the two most frequently used are frequency modulation and amplitude modulation. The former is used only in radio systems operating at very high frequencies. The latter is used in carrier systems.

One method of amplitude modulation is to use the circuits of Fig. 1. Assume a simple form for the voice voltage wave, wave A, which is connected to the circuit through a transformer. Wave B is the carrier voltage. Therefore, the voltage impressed on the grid of the tube is the series combination of the voice and the carrier voltages, wave C. If the C battery or bias of the tube and its characteristic are as in Fig. 2, the impressed voltage wave C will cause a plate current of wave form D. On the line side of the output transformer, current wave E will appear.

This wave contains the following principal frequencies:

- V: The voice frequency
- C: The carrier frequency
- 2V: Twice the voice frequency
- 2C: Twice the carrier frequency
- C—V: The difference between the carrier and the voice frequencies
- C+V: The sum of the carrier and voice frequencies

This can be easily demonstrated if the approximation is made that the plate current vs. grid voltage curve is parabolic in the range used.

Then (1)

$$i_b = K(E_b + uE_c + ue)^2$$

Where

- i_b: instantaneous plate current
- K: a constant

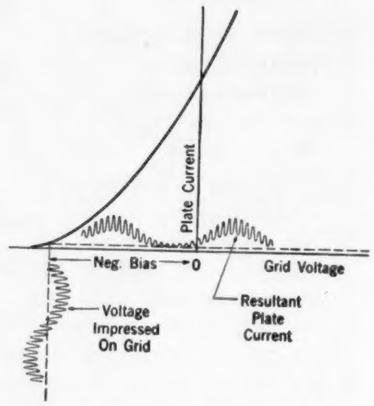


Figure 2. Vacuum Tube as Modulator.

- E_b: plate battery potential
- u: voltage amplification factor of the tube
- E_c: "c" battery or control grid biasing potential
- e: instantaneous alternating potential applied to the control grid

Assume that all except i_b and e are constants during the tube's operation, which is a good approximation. Upon expansion,

$$i_b = K[(E_b + uE_c)^2 + 2(E_b + uE_c)ue + u^2e^2].$$

Let

$$a_1 = 2Ku(E_b + uE_c)$$
$$a_2 = Ku^2$$

Then (2)

$$i_b = K(E_b + uE_c)^2 + a_1 e + a_2 e^2$$

In Fig. 1 both the voice and carrier voltages were represented as simple sinusoidal waves. Therefore their series combination, e, may be written (3)

$$e = A \sin Vt + B \sin Ct,$$

where A and B are constants.

Then

$$\begin{aligned} i_b &= K(E_b + uE_c)^2 + a_1(A \sin Vt + B \sin Ct) + a_2(A \sin Vt + B \sin Ct)^2 \\ &= K(E_b + uE_c)^2 + a_1 A \sin Vt + a_1 B \sin Ct + a_2 \sin^2 Vt + 2a_2AB \sin Vt \sin Ct + a_2 B^2 \sin^2 Ct \end{aligned}$$

(4)

Using $\sin^2 \Theta = \frac{1}{2} - \frac{1}{2}\cos 2\Theta$ and $\sin\Theta \sin\phi = \frac{1}{2}\cos(\Theta - \phi) - \frac{1}{2}\cos(\Theta + \phi)$,

$$i_b = K(E_b + uE_c)^2 + a_1 A \sin Vt + a_1 B \sin Ct$$

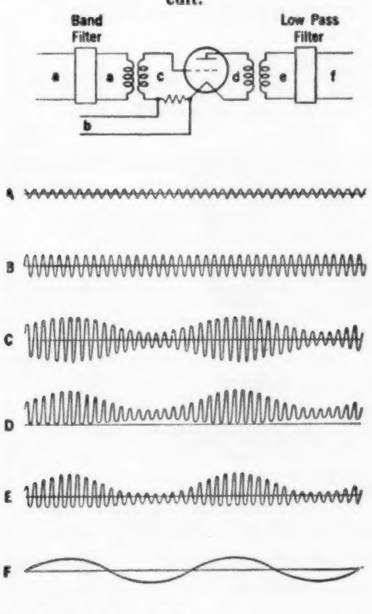
$$
\begin{aligned}
&+ \tfrac{1}{2} a_2 A^2 - \tfrac{1}{2} a_2 A^2 \cos 2Vt \\
&+ a_2 A B \cos (C-V)t \\
&- a_2 AB \cos (C+V)t \\
&+ \tfrac{1}{2} a_2 B^2 - \tfrac{1}{2} a_2 B^2 \cos 2Ct \\
= {} & K (E_b + uE_c)^2 + \tfrac{1}{2} a_2 (A^2 \\
&+ B^2) + a_1 A \sin Vt \\
&+ a_1 B \sin Ct \\
&- \tfrac{1}{2} a_2 A^2 \cos 2Vt \\
&- \tfrac{1}{2} a_2 B^2 \cos 2Ct \\
&+ a_2 AB \cos (C-V)t \\
&- a_2 AB \cos (C+V)t
\end{aligned}
\qquad (5)
$$

The first two components of i_b are zero frequency (direct current) and therefore will not appear on the line side of the output transformer. The next two components are amplified voice and carrier currents respectively; the fifth and sixth components have double the voice and carrier frequencies; and the last two are the $(C + V)$ and $(C - V)$ frequency components. These latter two components are usually referred to as the upper and lower side-bands. They are important because either one of them is capable of carrying the signal current to the receiving end of the circuit. In practice, often one side-

Figure 4. Voice Signal.

band is used to carry the signal and all other frequencies are suppressed by means of a filter. In Fig. 1, wave F represents the wave transmitted over the line after the band filter has suppressed all fre-

Figure 5. Currents in Demodulator Circuit.



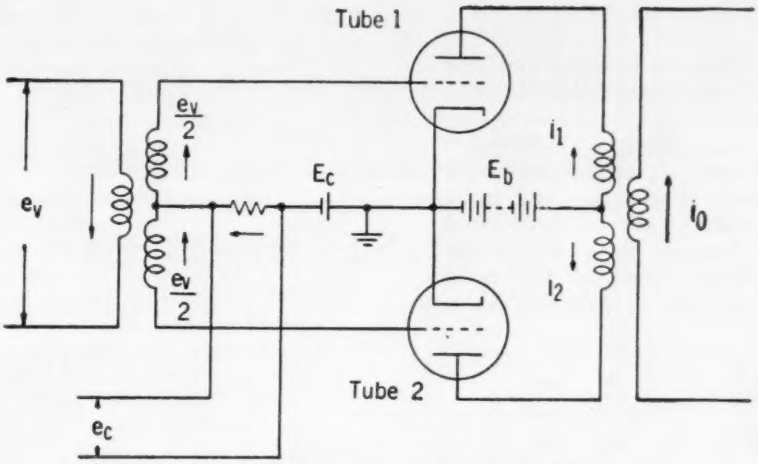


Figure 3. Balanced Tube Modulator Circuit.

quencies except the upper side-band, $(C + V)$. Proper adjustment of the constants a_1, a_2, A, and B will enable the greater part of the modulator tube's output energy to be utilized for the transmitted currents; i.e., all other components can be arranged to have amplitudes comparable with that of the upper side-band.

Another method of modulation employs the use of a balanced vacuum tube arrangement, such as in Fig. 3; this provides control of both the absolute and relative magnitudes of the output components. If operating conditions are ideal, this system will automatically suppress the carrier frequency and harmonics of either the voice or carrier frequencies. The circuit is constructed so that one-half of the voice voltage, e_v, is applied to the grid of each tube. However, the $e_v/2$ applied to the grid of tube 1 will be negative with respect to ground when the $e_v/2$ applied to the grid of tube 2 is positive to ground, and vice-versa. The carrier voltage, e_c, is applied in series with the grid biasing voltage, which is common to both tubes, and has the same polarity with respect to both at any instant. Therefore, the net alternating voltages applied to the tube grids at any instant are

$$
\begin{aligned}
e_1 &= e_c + e_v/2 \\
e_2 &= e_c - e_v/2
\end{aligned}
\qquad (6)
$$

Substitution of these values into equation (2) will give the plate current of each tube, thus

$$
\begin{aligned}
i_1 &= K (E_b + uE_c)^2 + a_1 (e_c + e_v/2) + a_2 (e_c + e_v/2)^2 \\
i_2 &= K (E_b + uE_c)^2 + a_1 (e_c - e_v/2) + a_2 (e_c - e_v/2)^2
\end{aligned}
$$

Since these currents oppose each other in the primary of the output transformer, the current there is $i_1 - i_2$.

The secondary current, i_0, is therefore $i_1 - i_2$ minus the direct current components, which are unable to pass through the transformer.

$$
\begin{aligned}
i_0 &= [a_1 e_c + a_1 e_v/2 + a_2 e_c^2 + a_2 e_c e_v + a_2 e_v^2/4] \\
&\quad - [a_1 e_c - a_1/2 + a_2 e_c^2 - a_2 e_c e_v + a_2 e_v^2/4] \\
&= a_1 e_v + 2 a_2 e_c e_v
\end{aligned}
\qquad (7)
$$

Let $e_v = A \sin Vt$ and $e_c = B \sin Ct$

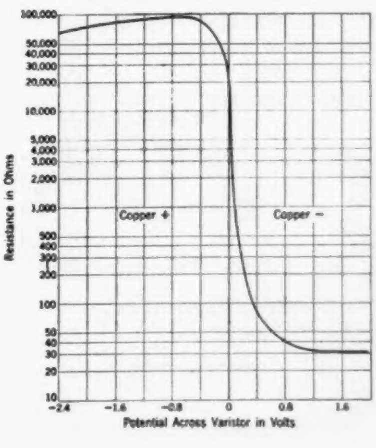
Then

$$
\begin{aligned}
i_0 &= a_1 A \sin Vt \\
&\quad + 2 a_2 AB \sin Ct \sin Vt
\end{aligned}
\qquad (8)
$$

Using $\sin \Theta \sin \phi = \tfrac{1}{2} \cos (\Theta - \phi) - \tfrac{1}{2} \cos (\Theta + \phi)$,

$$
\begin{aligned}
i_0 &= a_1 A \sin Vt \\
&\quad + a_2 AB \cos (C - V)t
\end{aligned}
$$

Figure 6. Resistance Characteristic of Copper-Oxide Varistor.



$$- a_2 AB \cos (C + V)t \qquad (9)$$

Thus the balanced tube modulator circuit output includes only the voice frequency and the two side-bands. Making B much larger than A insures that the greater part of the output energy will be represented by the side-band terms.

Because the actual current vs. voltage curves of the modulator tubes are not parabolic, additional

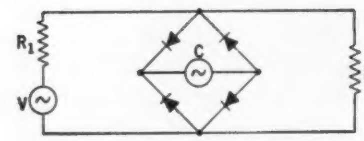


Figure 7. Balanced Bridge Modulator Circuit.

frequency components will appear in the output. Also the applied voice signal is usually a combination of several different frequencies (Fig. 4). Inter-modulation between these signal frequencies will result; some of the resultant harmonics or sum and difference components may lie within the frequency range of the useful side-band, thus leading to distortion. Since these disturbing frequencies are a result of the original voice signal, making the carrier voltage much larger than the signal voltage will greatly reduce their distorting effect.

In demodulation, the retrieving of the signal from the modulated carrier wave, basically the same curcuits are used as in modulation (Fig. 5). Wave A represents the incoming side-band, which is assumed to be the upper side-band carrying a sinusoidal voice signal. Wave B represents the voltage added to A and is of the same frequency as the carrier. Wave C is the net voltage impressed on the grid, equal to $(c+v) + c$. Substitution for e in equation (2) will show the resultant current to have the following frequency components:

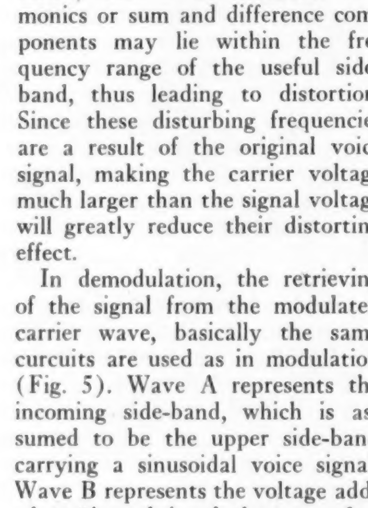
- c: The carrier frequency
- $(c+v)$: The impressed side-band frequency
- 2c: Twice the carrier frequency
- $2(c+v)$: Twice the impressed side-band frequency
- $(c+v) + c = 2c + v$: The sum of the impressed side-band and the carrier frequencies
- $(c+v) - c = v$: The difference of the impressed side-band and carrier frequencies, which is the voice frequency.

In Fig. 5, wave D represents all of these components; wave E, the current on the secondary side of the output transformer; wave F, the voice current, after the higher frequencies in E have been suppressed by a low-pass filter. In the balanced tube demodulation circuit, if the upper side-band is impressed, the output frequencies will be V, (C+V), and (2C+V).

A third type of modulation circuit employs copper-oxide varistors. The varistor is applicable because its resistance varies greatly with the magnitude and the polarity of the applied voltage, as shown in Fig. 6.

For use in channel circuits of carrier systems, four disc-shaped units, each 1/16 inch in diameter, are mounted in a small container. These units are very stable and have a very long life. The most common method of connecting these units in carrier systems is the bridge arrangement of Fig. 7. The arrowhead indicates the direction of applied voltage for low varistor resistance and therefore the direction of large current; the crossbar, the direction of high resistance and small current. The carrier voltage, C, is made large compared with the voice voltage, V. Thus the response of the varistors is almost entirely due to the fluctuation in the instantaneous carrier voltage; i.e., the varistor resistance varies at the carrier frequency. This effect is approximated by the circuits of Fig. 8. When the carrier voltage is positive, the voice voltage is allowed free transmission; when the carrier voltage is negative, the voice voltage is blocked from the line. The output current from this arrangement is shown in Fig. 9.

Figure 8. Operating Principle of Circuit of Figure 7.



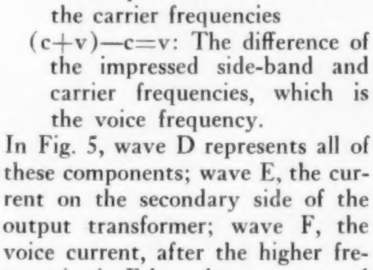


Figure 9. Output Current of Balanced Bridge Modulator.

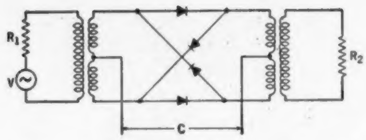


Figure 10. Lattice Modulator Circuit.

Assume a sine wave form for the voice voltage:

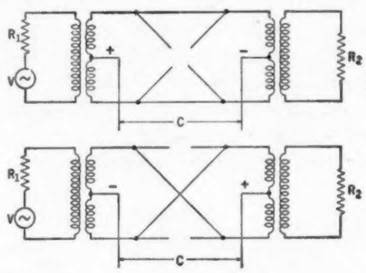


Figure 11. Operating Principle of Circuit of Figure 10.

$$e = A \sin Vt$$

where A is the amplitude of the voice signal and V is 2π times the voice signal frequency. The output current (Fig. 9) can be approximated as follows:

$$I = \frac{A\ Q\sin Vt}{2(R_1+R_2)} + \frac{2A}{\pi(R_1+R_2)}$$

$$I = \frac{A \sin Vt}{} + \frac{2A}{}$$

$$[\sin Vt \sin Ct + 1/\ \sin Vt \sin 3Ct + 1/5 \sin Vt \sin 5Ct + \ldots] \qquad (10)$$

C is 2π times the carrier frequency. Using $\sin \Theta \sin \phi = \frac{1}{2} \cos (\Theta - \phi) - \frac{1}{2} \cos (\Theta + \phi)$,

$$I = \qquad + \qquad \pi(R_1+R_2)$$

$$I = \frac{A \sin Vt}{2(R_1+R_2)} + \frac{A}{\pi(R_1+_2)}$$

$$[\cos (C - V)t - \cos (C + V)t + 1/3 \cos (3C - V)t - 1/3 \cos (3C + V)t + 1/5 \cos (5C - V)t - 1/5 \cos (5C + V)t + \ldots] \qquad (11)$$

The first three terms represent, respectively the voice frequency and the lower and upper side-bands of

(Continued on page 54)

History of Steelmaking in America

by FRANK F. WALSH, ChemE '59

Although the science of ironmaking has been known to man for over five thousand years, its history in the United States has covered the comparatively short span of three hundred years. The American Indians had no knowledge of iron manufacture even in its most primitive form. So it was the early colonist, with his background of European iron making, who made the first iron on this continent.

From these beginnings, in this comparatively short period of time, the United States has not only risen to the position of first among iron and steel producing countries, but it has also advanced so far that its annual output of iron and steel is greater than the combined yearly output of all the other producing nations in the world.

British Pioneer Early Virginia Mining

It was not until 1585 that the first discovery of iron ore deposits in America was made. At the time, Sir Walter Raleigh's men, who made the discovery, were so unimpressed that when they returned to England they did not take even a sample of the ore with them. These deposits were soon forgotten and it wasn't until early in the senventeenth century that Britain decided to do anything about developing the possible sources of iron in America. At this time, the iron industry in Great Britain was using large quantities of wood for charcoal, and at the same time was destroying the forests which were so urgently needed to keep up the navy.

As a solution to her problem, England decided to send an expedition to America to see what could be done about developing an iron industry there. When the settlers at Jamestown, Virginia, reported in 1607 that they had found "an abundance of iron ore" along the James River, an expedition of skilled iron miners and blast furnace operators along with their families was fitted out and sent to the new world to develop what was hoped would become a flourishing iron industry able to send products back to England.

Indians Block Ironworks Construction

For several years only iron ore was exported to England from the United States, and no attempt was made to set up an ironworks. Finally, in 1619, a company was organized to erect three ironworks in Virginia. An ironworker whose name was Captain Bluett and eighty workers were sent to Virginia to select a good location for the first ironworks. They decided on a site along a creek in what is now Chesterfield County.

The company ran into many difficulties during the erection of the works and it wasn't until 1622 that the works was ready for operation. Great excitement was felt in both England and the colonies as the opening day of March 22 approached. The local Indian tribes, unable to understand what was going on, also became excited, and on March 22, as the colonists were making final preparations, a horde of Indians descended on the settlement and massacred all of the colonists except for one who escaped to tell of the great tragedy. From time to time, attempts were made to revive interest in ironmaking in Virginia, but none of these plans materialized and it wasn't until many years later that any iron was produced in the state.

Successful Ironworks Is Opened In Massachusetts

The second attempt at building an ironworks was made in Massachusetts in the town of Saugus. In 1643 a company of stockholders was granted special privileges by the General Court of Massachusetts and sometime late in 1644 the works was completed and put into operation. This first successful ironworks in America has recently been restored and is now open to the public. Following the successful operation of the works at Saugus, a number of ironworks were opened in Massachusetts and other colonies by new companies, and the iron industry in America was soon booming.

The pioneer ironworks seem to have attracted mainly the adventuresome young men ranging from twenty-five to thirty years of age. Of these men, there were two main groups: the freemen and the indentured servants. The indentured servants agreed to work for the company for seven years in return for their food, clothes, living quarters and passage to the colonies. At the end of this time they were given a small bonus and were free to do what they wanted. In the colonies, ironworkers were given special privileges, to encourage more young men to become interested in the industry and, on the whole, the workers fared better than the average citizen.

Because of the great demand for iron in the colonies, the iron industry grew rapidly, and soon ironworks were appearing in all sections of the colonies. The success of the iron industry in America was also aided greatly by the able men who directed its progress. In the history of iron in America can be found the names of several families whose

descendants have been influential in the industry for several centuries.

Due to lawsuits and difficulties with settlers living in the area, the production of iron at the Saugus works finally became unprofitable, and in 1688, after forty-four years of operation, the works closed for good. However, Massachusetts remained the main center of iron production in America for over half a century after the closing of the Saugus works.

Penn Encourages Iron Industry

William Penn, founder of the state of Pennsylvania, became interested in starting an ironworks in his colony and, as early as 1683, tried to interest colonists in developing the resources there. It wasn't until 1716, however, that any iron was produced in Pennsylvania.

The great "iron plantations" of Pennsylvania were very similar to the large plantations of the South. The owner of the plantation was responsible for the building of not only the forge and other work buildings, but also houses for the workmen, a schoolhouse for the children, a general store for the convenience of the townspeople, and any other buildings which were necessary. Like the Southern plantations, the iron plantations were self-sufficient communities which produced not only iron products, but also clothing, food and other necessities of the community.

Ironmaking Becomes Important Colonial Industry

By 1750 ironmaking had become one of the colonies' most important industries. The plantations of the period served as a transition between the smaller furnaces which had previously existed and the big industry to come. Wood was being used at a tremendous rate since charcoal was the only fuel used at the time. Much of the cast iron turned out at this time was molded into very artistic shapes.

Nearly a century passed following the destruction of the first works in Virginia before another attempt was made at establishing an ironworks south of Pennsylvania. Largely through the efforts of the Governor of Virginia, Colonel Spotswood, an ironworks was started in 1714 in Virginia and another works soon followed it. By 1730 these two works were shipping large quantities of iron to England.

In 1750, England, not wanting to compete with the colonies in the production of iron and steel products, but needing the iron for manufacturing purposes of her own, passed an act to regulate the building of mills for manufacturing and working iron and steel. The colonists were quick to see the effect of this act on their industry and did not cooperate with the British any more than was necessary.

Iron Masters Support Independence

The many restrictions and impositions of England on the iron industry in America did not result in any outstanding actions by the ironworkers; however, by the start of the Revolutionary War a large majority of the ironworkers were ready to back up the colonies in their fight for independence. Many of the ironmasters were prominent men in their colonies and a large number were officers of high rank in the Continental Army. Five of the signers of the Declaration of Independence were ironmasters, and a number of other signers of the Declaration of Independence can be traced directly to the families of ironmasters. Probably the most famous ironmasters of the Revolutionary War period were General Daniel Morgan, General Nathaniel Greene, and Colonel Ethan Allen.

In the campaigns of the Revolutionary War, the destruction of the American ironworks was one of the main objectives of the British Armies, for their destruction would be a strong blow to colonial ammunition and arms supplies. Most people don't realize that Valley Forge was the site of an ironworks which was destroyed by the British before General Washington chose it as the location for his army's encampment during the winter of 1777-1778.

War Stimulates Industry Build-Up

With the start of the Revolutionary War, a number of steel mills, forges, and slitting mills, whose erection had been outlawed by England before the war, were built. Even with these new mills, iron production facilities in the colonies were too small, and many states offered various types of inducements to encourage the building of more ironworks. Ironworks were able to cast only cannonballs and cannons,

"Hopewell Village Iron Plantation."

—*U. S. Steel Corp.*

—U. S. Steel Corp.

"Ruins of Hopewell Village blast furnace."

so other weapons had to be made by artisans and gunsmiths.

Although New York was one of the last colonies to enter into the ironmaking industry, it made large contributions to the colonial fight for independence. Most notable of the activities in the iron industry in New York was the construction of a large iron chain which was strung across the Hudson River at West Point to keep the British fleets from taking control of the river and cutting the colonies in half. The completed chain was five hundred yards in length and each link was two feet long, weighed one hundred pounds and had a cross section which measured two and one-fourth inches square. The total weight of the chain was about one hundred eighty tons.

Industry Production Lags

The Revolutionary War caused a drastic reduction in the development of the iron industry in America. In the year 1775, the colonies turned out over fourteen percent of the total iron production in the world; but, by 1790, the amount of iron produced in America had dropped to less than twelve percent of the total world production. Not until after the Civil War did the United States again produce over fourteen percent of the world's total iron production.

The main reasons for the slowing of production of iron in America were: the destruction of the ironworks by the British, the lack of workers due to the large number of ironworkers who went to join the armies of the colonies to fight England, the primitive design of the ironworks which were becoming more and more outclassed by European ironworks, and the loss of England as a market which had formerly absorbed one-fourth of the iron produced by the colonies. In addition to this, Europeans had been experimenting with different methods for improving iron production while the colonies had been fighting the Revolutionary War, and had had no time for experimentation.

Expansion, Good Working Standards Mark Industry Growth

For about the first one hundred fifty years of its history, the iron industry had been concentrated in the eastern colonies. However, by the end of the eighteenth century, it had started to move west with the pioneers. The first works west of the Allegheny Mountains was established in Fayette County, Pennsylvania in 1790, and the works in Kentucky soon followed, in 1792, along the Slate Creek in Bath County. One of the most important products produced from iron was nails. Their production was done entirely by hand so that many families spent the long winter nights making nails from bar iron. In 1790, one of the leading mechanical geniuses of the nineteenth century patented a machine which made possible the production of nails at the rate of 200,000 a day by one man. This invention was one of the first of many changes in the methods of producing and working steel.

The start of the nineteenth century found the living standards of ironworkers better than workers of most other industries. Their wages were only one dollar a day, but because prices were much lower and because the worker's family raised most of the food it ate and made most of the clothes it wore, the worker and his family could live very comfortably on his pay. Writings and records show that each member of a family could be supported comfortably on sixteen to twenty cents a day, depending on the locality in which the family lived.

Technical Improvements Raise Steel Quality

The outlook for the iron and steel industry in the United States at the turn of the eighteenth century was not good. American iron producers were still looking for a way of producing steel comparable to the crucible steel made in England. By 1835 a method of mixing and heating steel in clay crucibles had been discovered and perfected so that the steel produced in America by 1837 was as good as England's.

The growth of the iron industry in the United States during the period from 1800 to 1850, while not outstanding, was good. The annual production of iron and steel in America jumped from 50,000 tons in the year 1800, to 185,000 tons in 1830, to 900,000 tons during the years just prior to 1850. During this period, new iron regions were also opened up so that ironworks spread through all of the original thirteen colonies and many others. During this time, the first ironworks of the South was opened along with works in such now-important iron and steel centers as Cleveland, Detroit and Buffalo. The use of the hot air blast in place of the cold air blast and the use of coal and coke in the place of charcoal were introduced to increase production, during this period.

When the iron industry was first introduced in the colonies, early in the seventeenth century, Connecticut was among the leaders in the production of iron. The famous Salisbury iron was produced in several of the Connecticut works. However, when the industry changed over to coal and coke for fuel, during the early nineteenth century, Connecticut did not have the necessary deposits of coal and was forced out of the competition.

New England, New York Iron Industry Grows

During the 1800's, in Vermont, many of the ironworks were supported by barter. Many of the ironworks opened general stores where the families of the workers could buy supplies; these stores also served as an outlet for the goods received in trade for iron and iron products. This system of barter and disposing of the goods worked very satisfactorily for a number of years.

The iron industry of Vermont attracted many varied types of men as owners. Records show that one ironworks in Vermont had among its owners a retired Congressman, a former commissary of the Revolutionary War, an Irish insurrectionist who had fled from Ireland for his life, a newspaper editor, and an ex-foreign diplomat. By the end of the Civil War, the development of the iron industry in Pennsylvania had forced many of the Vermont ironworks out of business and the Vermont iron industry was on the decline.

With the start of the nineteenth century, the iron industry of New York state began a steady move north and west with the pioneers. With the completion of the Erie Canal, the Lake Champlain district had become the most important iron-producing section of New York state. The development of the Lake Champlain area continued to increase until, by the 1880's, the amount of iron ore shipped from the Essex Counties alone was twenty three percent of that produced in the United States.

During this same period of time, in the early 1800's, the iron industry in New Jersey was being developed rapidly. The Oxford furnace, which was located in Warren County, New Jersey, had the distinction of having the longest record of operation of any furnace during the eighteenth and nineteenth centuries. Peter Cooper, the famous inventor and philanthropist of New York, was a leading figure in the history of the New Jersey iron industry. He built several ironworks and experimented with the Bessemer process of making steel. Along with that of several other states, the iron industry of New Jersey started to decline about 1870.

Pennsylvania Development Marks National Industry

During the first part of the nineteenth century, the iron industry in Pennsylvania, and particularly that of eastern Pennsylvania, expanded greatly. This expansion was due largely to the abundance of high grade raw materials and the convenient location of these raw materials. The introduction of anthracite coal in place of bituminous coal about 1840 further increased the output of Pennsylvania works and secured the position of Pennsylvania as the leading producer of iron and steel in the United States.

Until the time of the establishment of the iron industry in Pittsburgh, Pennsylvania, the iron industry had been mainly a localized industry with each mill supplying only the needs of the nearby communities and farms. However, with the establishment of the iron and steel mills at Pittsburgh to produce pig iron and iron products for the pioneers, the iron and steel industry took on a national aspect. In 1789, an emigrant by the name of Anshutz erected the first furnace in Pittsburgh. By 1810, a forge had been built to work some of the pig iron produced in the Schuykill and Juniata ironworks. The iron and steel industry in Pittsburgh grew rapidly and by 1825, the mills were employing 1500 people and doing a $3,000,000 a year business.

During the years between 1800 and 1850, the iron industry in the South grew rapidly. The increasing use of railroads during this period created the need of a large number of rails which, in turn, caused an increasing need for iron. The production of military goods for the war of 1812 helped to increase the demand for the Southern works' products. By 1844, one Southern works was even building an iron revenue cutter for the government.

Bessemer Process Increases Quality Production

In addition to the change from charcoal to anthracite coal and coke in the production of iron and steel, the first half of the nineteenth cen-

The Ironton plant of the Columbia-Geneva Steel Division, U.S. Steel Corporation, two miles south of Provo, Utah. The plant produces pig iron, coke and coal chemicals.
—U. S. Steel Corp.

tury brought another great improvement to the iron and steel industry—the Bessemer process for producing steel from iron. With these two changes and the use of the hot air blast instead of the previous cold air blast, iron and steel production increased rapidly.

Although ironworkers had been experimenting with the use of coke in ironmaking in England since the early part of the eighteenth century, the first successful use of coke in producing iron in the United States took place in 1835. The use of coke in ironmaking became more widespread after 1850. Until the First World War, coke was produced by the bee-hive method which was used when coke was first introduced in ironmaking in the United States.

One hundred years ago, iron was the world's basic metal. Steel, because of its high cost of production, was used at that time only for the manufacture of fine edge tools. Since the introduction of the Bessemer and Open Hearth processes for making steel, however, the amount of steel produced has increased until, at the present time, steel comprises over ninety percent of all the metals produced in the world. The Bessemer process for making steel was named for Sir Henry Bessemer who invented the process in England. He had it patented in England in 1855 and in the United States in 1856. However, unknown to Bessemer, an American steel producer, William Kelly, had perfected the same method five years earlier, in the year 1850. Kelly had neglected to protect his invention with a patent and was forced to file a claim of priority of invention in order to get a patent for his invention. The first commercial heat of steel produced by the Bessemer process was made in 1864, and after that, steel production in the United States increased rapidly.

Civil War Focuses Steel Demand

Iron and steel manufacturing played a large part in the Civil War for both the North and South. For the South, the production of iron for weapons was a struggle throughout the war, especially since the Birmingham iron district had not been developed at that time. Although the South's production of iron was far greater than anyone had imagined was possible, the ironworks were still unable to keep up with the need. Both the North and the South started using the Bessemer process for producing steel for weapons in 1864, but, by that time, the war was so nearly over that the supply of steel had little effect on the outcome of the war.

Replacement Need Sparks Ohio Industry

One of the biggest problems of the pioneers was obtaining objects made of iron and replacements for broken iron implements. Because transportation was so slow and ironworks produced products for neighboring communities only, pioneers were often forced to attempt to make iron to supply their own needs. Occasionally, these attempts were so successful that the pioneer would give up farming and take up ironmaking. One such attempt at ironmaking was made by John Deering of Kentucky about 1800. He was so successful at producing iron that other pioneers became interested and soon the Hanging Rock region along the Ohio River became one of the most important iron producing areas of its time.

Trenton Is Home of First Open Hearth Plant

Because the Bessemer process could not be used for producing steel from scrap iron and scrap steel, a better method of producing steel was needed. In 1861, an improved process, known as the Open Hearth process, was invented by an Englishman, Karl Siemens. This method for producing steel from scrap iron and scrap steel as well as from pig iron was brought to America by an employee of an American iron company. The first open hearth plant in America was built in Trenton, New Jersey, but it was forced to close by a long string of bad luck after only two years of production. The second open hearth steelworks was constructed in South Boston, Massachusetts. A few changes were made in the original plant's plans, and the new works was so successful that a number of other companies became interested in the process and opened plants. Today, ninety percent of all the steel made is produced by the open hearth process.

Superior Region Supplys Ohio Ironworks

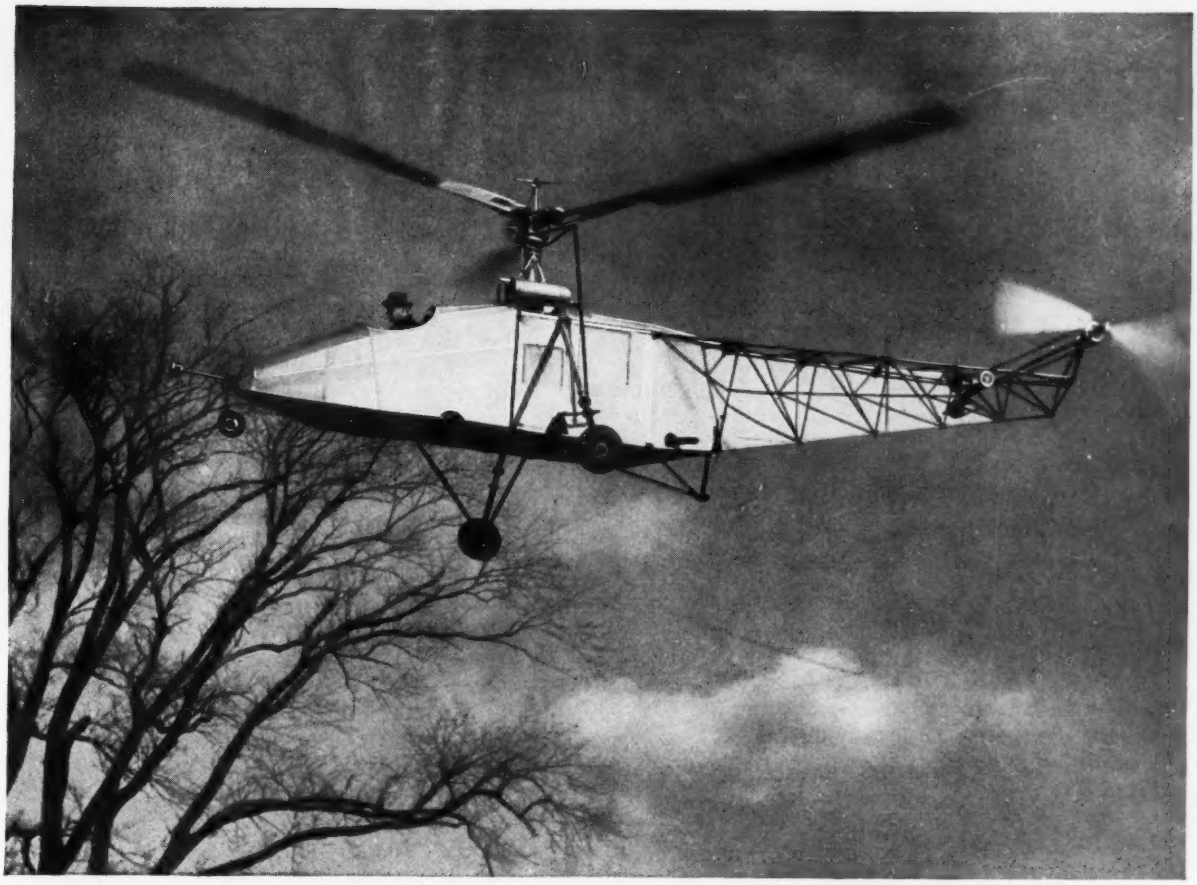
Since the opening of the first ironworks in Ohio years ago, the nearness of raw materials has insured the success of the area as an iron manufacturing district. The large number of railroads in the area and the abundant coal supplies nearby also aided in the development of the area. With the Lake Superior iron ore deposits nearby, northern Ohio has become one of the leading producers of iron and steel in the United States.

Although high grade iron ore was discovered in the Lake Superior area as early as 1840, people were slow in opening the area for mining. By 1875 the only range which had been opened was the Marquette Range. The ore which was being mined was of such uniformly high quality, however, that soon other ranges were opened and by 1885 there were four ranges in operation. The Mesabi Range, the largest producing range today, was not discovered until 1892, but because the ore was so near to the ground that it could be shovelled out instead of being mined, the range was soon producing more iron ore than any other area in the United States.

Chicago-Calumet Area Becomes Steel Center

Even though the development of the Chicago area as a leading iron and steel producing area was late in starting, the area had an excellent location which aided its development. Because Chicago lay on the main land and water routes connecting the East and the West, it was destined to become a great industrial center. The history of Chicago's iron and steel industry can be said to date from 1857 when a rolling mill was established to reroll railroad rails. It wasn't until ten years later, however, that the first ironworks was established. A large number of other furnaces and mills soon followed, and by 1876 Chicago was producing one third of the railroad rails made in the United States. Within a few years new furnaces appeared south of Chicago in the area now known as the Calumet District. The importance of Chicago, itself, as an iron

(Continued on page 55)



Simple enough now, this vertical ascent was history-making in 1939.

You can remember
THE FIRST SUCCESSFUL HELICOPTER

Just two years *before* Pearl Harbor, Igor Sikorsky took the controls of a weird-looking machine — culmination of a dream of thirty years. Moments later it rose from the ground. Though the flight lasted only a few seconds, the VS-300 became the first practical helicopter in the United States.

Less than six months *after* Pearl Harbor, the Air Force took delivery of the first military Sikorsky.

Since then, rapid developments prove that the helicopter, most versatile of military aircraft, has tremendous commercial potentials.

Helicopters of the future will be the product of tomorrow's engineers. Sikorsky is young and growing. It offers life-time opportunities to young men who choose work where their skills and abilities will be constantly challenged.

Perhaps *you* belong at Sikorsky — in the research departments, the drafting rooms, the engineering laboratories.

You can *remember* the first successful helicopter — you may be the man to *build* tomorrow's! Learn more about employment opportunities at Sikorsky. Consult your College Placement Office concerning arrangements for a personal interview.

SIKORSKY

Sikorsky Aircraft, one of the divisions of United Aircraft Corporation, South Avenue, Bridgeport 1, Conn.

Engineering Displays at Farm and Home Week

A variety of displays ranging from oceanography equipment to automatic milking systems were presented at the annual Cornell Farm and Home Week, held this year from the 21st to the 25th of March. Included in the displays were examples of work related to underwater exploration and the dairy industry, combined with general exhibits on the problems of agricultural engineering, illustrating the growing application of engineering techniques in food raising

The Oceanograph equipment and methods were shown in Ferrow Hall. The apparatus on display has been used in summer research projects carried out in the Great Lakes and off the East Coast of the United States. Scientists involved in these projects were particularly interested in obtaining data on salt content, ocean-floor material, water samples at varying depths, and on the variation of temperature with depth.

A graphical record of fathometer readings indicated the nature of the ocean floor investigated during a trip southward in the Atlantic to Bermuda. The fathometer produces a continious record of peaks and valleys in the ocean floor by means of a recording mechanism similar to a barograph. In principle, the farthometer is a rader set, and derives its data from analysis of signal pulses reflected from the ocean floor.

Other devices included the "von Arx current meter," which measures the speed of ocean currents by means of a propeller-driven generator. The generator provides a direct velocity reading on a properly calibrated micro-ammeter. Thermisters are used in underway study for temperature measurement. The thermister unit includes a line graduated according to depth, giving a rapid correlation between depth and temperature. A "wave-force-meter" uses simply a plate constructed of lead and suspended in inverted semicircular cradle. The displacement of the plate, in operation, indicates the magnitude of wave forces by means of graduations on the perimeter of the cradle.

A torpedo-shaped container carrying its own recording equipment obtains temperature and pressure data beneath the ocean surface. Called a "bathy-thermograph", the device is suspended from the "mother ship" along with specially constructed sampling bottles which are arranged to admit water samples at predetermined depth levels. A remotely-constructed claw-like scoop called an "orange peel" sampler is employed to collect ocean floor samples for later exluation.

Other protions of the Fernoe Hall exhibit included a tube containing fluids of various densities rigged to illustrate the formation of standing waves and turbulance capable of inflicting damage to underwater structures. Diving suits were displayed, along with a large three dimensional cutaway model of a typical off-shore bottom contour, indicting the areas where Cornell studies have been made. Undersea research at Cornell is under the direction of J. C. Ayres, associate professor of Oceanography.

Automatic Milking Features

Pipeline milking systems, including new methods for automatic washing during all parts of the operation were presented among other displays at the dairy industry building, Stocking Hall. Pipeline milking equipment handles the entire milking process automatically, from siphen-breaker cups attached to the cows, to regulation of the dairy's bulk milk storage tanks. Designed to promote convenience in operation, the pipeline system provides raised stalls for each cow which enable the operator to quickly attach the collecting-up assembly, and to keep the equipment clean with a minimum of complication. Milk from the cow is obtained by a unit which properly stretches the udder, and then filters the milk to reduce impurities.

The milk is then carried under vacuum in a pipeline (glass or stainless steel) to a "releaser," which brings all collected liquid to atmospheric pre-sure for immediate injection into the storage anks. This method of delivering milk to bulk tanks enables the farmer to eliminate cans and mechanical coolers, and to avoid collapsing problems inherent in other systems of reduced-pressure storage.

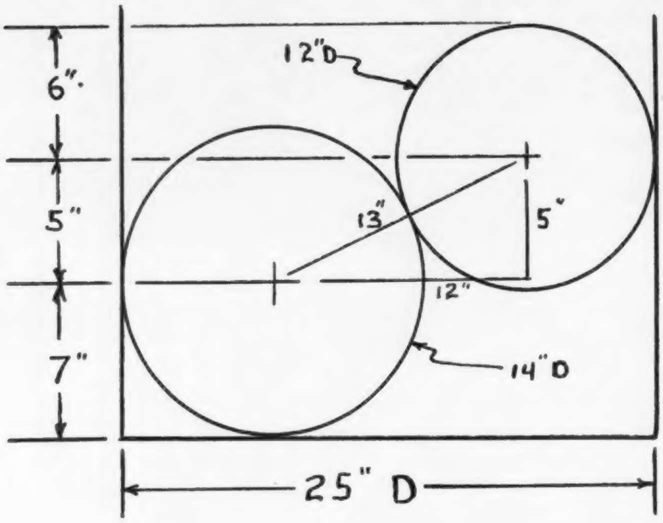
The "parlor-milking" innovation in modern dairying was illustrated in the exhibits by the automatic washing system included with the milking lines. The washer sequence in governed by a solenoid control mechanism. The first step involves injection of water at 105 degrees F to rinse the hoses and carry away all liquid milk. Next, water at 180 degrees is admitted and a detergent is passed into the system. Following this twenty-minute operation, a third wash containing disinfectant completes the washing job. The machine then automatically drains and shuts itself off.

The milking equipment also includes a safety valve which shuts off the vacuum in the milk lines in the event of difficulty. The pipeline milker, combined with Cornell's six-month old automatic washer, reduces dairying time by carrying out processes previously done manually.

Ag Engineering Displayed

Agricultural engineering was presented as a vocation with a variety of opportunities at exhibits located in the new agricultural engineering building. Among the dipslays were methods for proper building and locating of fences, electric chick brooding, and proper road-surface treatment. Bituminous road surfaces were analysed from the standpoint of drainage base, and causes of failure. Production of asphalt materials was outlined. Other displays in the section were an explantion of Cornell Agricultural Engineering training, a presentation of the methods for aluminum usage in farm equipment and buildings, and a number of modern farm machines including pneumatic harvesters, chopped-hay conveyer distributors, and silo unloaders.

Brain Teasers



Last month we proposed several quite simple problems, the first of which involved putting two steel balls with diameters of 14 and 12 inches in a cylindrical can of diameter 25 inches. A glance at the sketch will show that 18 inches of water are needed to cover the spheres.

Our second question wanted to know how fast one would have to travel on a return trip if the outgoing leg had been made at 30 mph in order to average 60 mph for the whole trip. Well, this situation is an impossibility, since all the time available for the trip (if one is to average 60) has been used up already.

In proving that one equals two in the third question, we made the error of neglecting to take all possible roots. As a result,

$(1-3/2)=(2-3/2)$, but also,

$(1-3/2)=(2-3/2)$, which reduces to the more acceptible identity that one equals one, as in days of yore.

Lastly, in a search for words with double vowels, while avoiding the use of proper names, one might come up with: aardvark, seed, skiing, tooth, and vacuum.

Now on to a few new ones. The ENGINEER pays three dollars for the first correct entry, and very little

effort is required, so why not write the answers to the puzzles below on a postcard and send them in?

1. A professor and two of his assistants have been cornered in the Libe tower by an angry mob of students who have just taken one of their prelims. Thoughtfully, some workmen have left a pulley arrangement hanging near one window, as well as a 75 pound weight. Since each end of the rope over the pulley has a basket on it, it is decided by the three desperate martyrs to lower themselves to the ground by this means. However, due to a thorough knowledge of engineering lore, it is apparent that an unbalance of more than fifteen pounds on either end of the pulley rope would destroy the balance and hurl the occupant of the basket to a bloody death on the sidewalk below. Since we have sworn affidavits that the professor weighs 195 pounds, and his assistants 105 and 90 pounds respectively, we must ask you what procedure the men followed in safely lowering themselves to the ground.

2. For the benefit of those who have taken some engineering law courses, we should like to know whether it is legal for a man to marry his widow's sister.

3. You have two current United States coins in your hand. Together they total fifty-five cents. One is not a nickle. What are the coins?

Will the good professor escape from the tower and make it safely back to Sibley? See next month's Brain Teasers for the answers.

Retiring Board Members of the Cornell Engineer

With this issue of the CORNELL ENGINEER, five officers of our publication board will allow their responsibilities to pass on to the hands of successors recently elected for the coming year. Here are photos and biographical sketches of the retiring officers, which we proudly present with appreciation for the fine management the ENGINEER has received during the past twelve months. To these men the new staff extends best wishes for the future.

JOHN F. SCHMUTZ, Chem. E. '55 from Palmerton, Pennsylvania, this spring concludes four years of work on the ENGINEER, after having served in 1951 and 1952 on the editorial board, 1953 as associate editor, and since last spring, at the top of our ladder as editor-in-chief.

Jack is one of our really energetic engineers, and has succeeded in mixing studies with "co-curricular" work in many fields, all with fine results. He has been on Dean's List for three years, stands first in his class, and holds a McMullan Regional Scholarship. In addition, Jack has been treasurer of his fraternity, Pi Kappa Phi, secretary of Tau Beta Pi, and is a member of Pros-ops (Chem. E. honorary), Pi Delta Epsilon and Sigma Delta Chi (both journalism societies), Phi Kappa Phi.

As for non-official interests, Jack, while in favor of "sports in general", especially enjoys golf and skiing, the latter in spite of a wrist and his nose each having once been broken due to that activity. His particular favorite for vacation-times, however, is fishing in Maine.

Jack's recent summers, with the exception of '53, which was claimed by the Air Force for ROTC camp, have been working for Bethlehem Steel, New Jersey Zinc, and last summer, for the Socony Vacuum Oil Company, where Jack was in the research and development labs, occupied with various aspects of catalytic cracking.

After graduation in the coming June, Jack hopes to receive a commission from the Air Force, and plans eventually to study patent law at night law school while working daytimes at a private law firm or patent division of a large company.

Somewhere in this set of plans is reference to Jack's girl; but in that subject, no specific announcement has yet been heard.

EDWIN A. LEVENTHAL, E. P. '56 from Brooklyn, New York, having reached his present position of managing editor of the ENGINEER via the associate editor's post, chooses to terminate his editorial duties with one year yet remaining before graduation so as to spend more time with his many demanding activities elsewhere on campus.

During the past year, Ed served as president of his fraternity, Sigma Alpha Mu. He is a member of Pi Delta Epsilon, Sigma Delta Chi, and the Cornell Society of Engineering Physics.

Ed's responsibilities as managing editor included planning the layout of pictures, articles, titles, and advertisments, as well as "dummying" the magazine for final printing. This is a job requiring thorough knowledge of the techniques of publishing. In addition to these duties, Ed has contributed several articles, such as "The Divining Rod," an analysis of this instrument and its uses.

Outside the realm of school activities, Ed's interests include photography, and bowling (a favorite). Summers have always been busy and interesting periods for Ed, and as an example, Ed tells of that a couple of summers ago his job for Swift & Co. took him into a freezer at -20 degrees F., where he worked most of the time storing large quantities of ice cream. Another summer, Ed took the same stuff out of the freezer, and another, he worked at a production job. For the coming summer, Ed plans to be in a more technical line of work,

Milton Cherkasky (left), Jack Schmutz, and Edwin Leventhal.
—Rod Glover

—Rod Glover

Bill Thurber (left), and Tom Reed.

and is now "dickering" with the Atomic Energy commission.

Ed's plan for the next few years is indefinite at this point, but he believes he will begin, upon graduation in 1956, at some form of experimental work, with the eventual goal of enlarging his contact with people, possibly by way of management work at an industrial research organization, or, referring to his interest in writing, by way of a career in technical journalism.

After two years on our staff, THOMAS C. REED, M.E. '56 from Greenwich, Connecticut, is retiring as associate editor this spring. A proven leader in his scholastic activities, standing first in his class, Tom displays interest and great ability in other fields, where his accomplishments include having served as president of his fraternity, Alpha Delta Phi, and president of Pi Delta Epsilon, honorary journalism society. He is a member of Tau Beta Pi, Sphinx Head, and the Cornell Glee Club, and was a counselor last fall at Freshman Camp.

To the ENGINEER Tom has contributed articles on a wide variety of subjects: from "Seismic Exploration for Oil" to recent "Brain Teasers;" and readers may remember "Some Observations of the Collegiatron" by Tom, which appeared last year.

As for plans for the future, Tom's thoughts are heavily engaged with the problems of the coming school year, when in addition to his senior project Tom will undertake a teaching job which he has secured with the University.

Although his official engineering field is mechanical, Tom finds his interests in engineering drawn strongly toward the affairs of electrical engineering. Now taking several courses in that field, he expects to carry out his fifth-year project next year under the guidance of the E.E. school.

Plans beyond graduation for Tom are largely dependent upon the Airforce, in which he is now enrolled as an ROTC student. After AF duty, Tom hopes to go into electrical engineering work, carrying with him, we remark, a fine personality and a deep background.

MILTON CHERKASKY, M.E. '55, is our retiring business manager, and comes from South Orange, New Jersey. Milt joined the business board of the ENGINEER four years ago, working up to his most recent position by way of the office of treasurer last year.

Making heavy use of his time at Cornell, Milt is double-registered with M.E. and the School of Business and Public Administration. He is former treasurer of his fraternity, Phi Epsilon Pi, and has been active with the Cornell Campus Chest.

Much of Milt's efforts during the past year have been spent successfully designing for the ENGINEER a scholarship fund program which which is expected to go into effect next yead. This project benefited admirably from Milt's knowledge of financial matters. In addition, Milt represented Cornell at the annual conference of the *Engineering College Magazines Association* last fall in Chicago, sponsoring for us the election of the *Princeton Engineer* to the organization.

Although quite busy with his variety of responsibilities much of the time, Milt occassionally has opportunity to enjoy a game of tennis or a skiing trip, these serving as his favorites in sports.

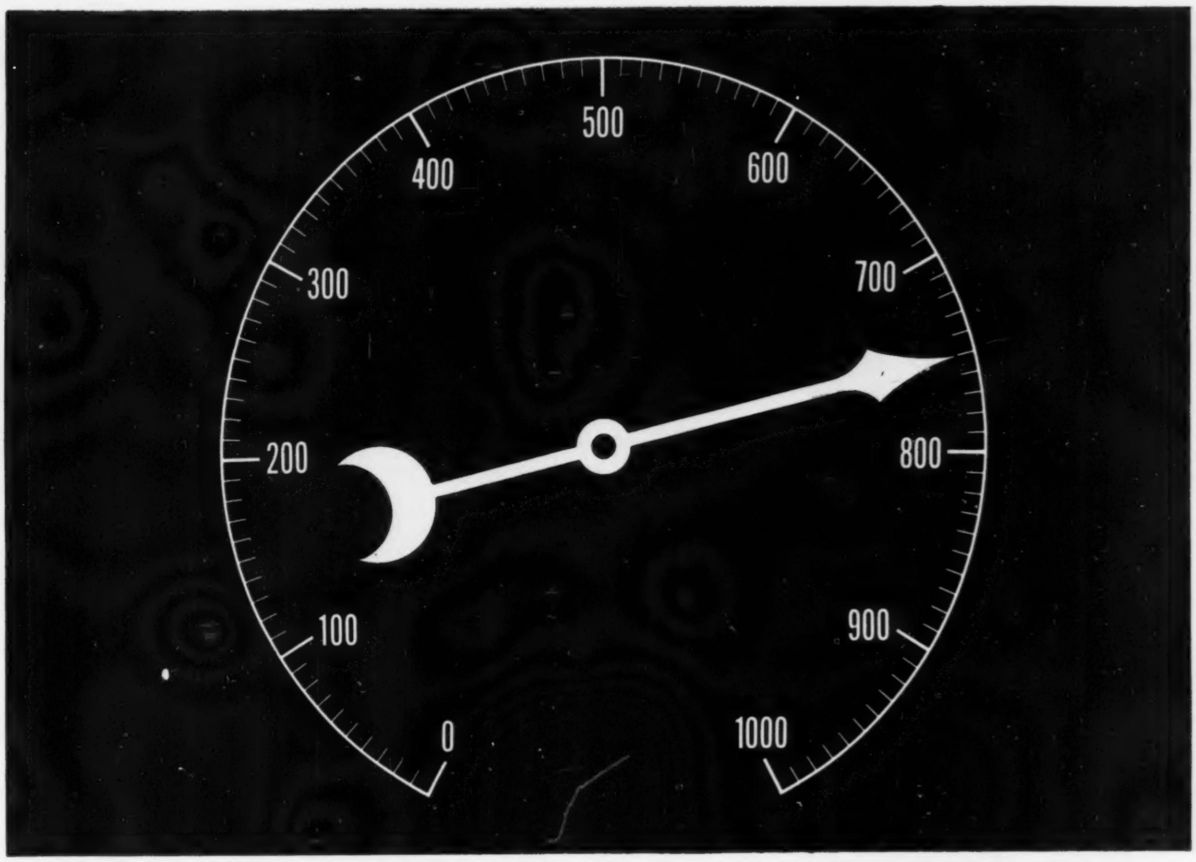
After graduation in June, Milt plans to go to work, with the goal of entering production engineering or the "business end" of manufacturing.

WILLIAM C. THURBER, Met. E. '55 from Rome, New York was a former circulation manager of the ENGINEER and is now our retiring treasurer. An active member of Alph Chi Rho fraternity, Bill is a member of Pros-ops, and this year is president of the Cornell Metallurgical Society, having been vice-president last year.

While a freshman, Bill earned his numberals in football, and has since played on the Cornell Varsity lacrosse team. He was on the Dean's List in 1953-54, and stands tenth in his class.

Last mid-term vacation Bill indulged his interest in skiing by taking a trip with a group of friends up into the slopes in Canada. Managing to keep quite busy during summer vacations, Bill worked last summer for the engineering division of Proctor & Gamble, part of the time in the metallurgy section and part in the mechanical process equipment section.

After finishing up his fifth-year project ("Effects of impurities on intergranular oxidation of zinc-base alloys"), Bill says his plans are somewhat up in the air, depending to a large extent on whether or not he is able to get a fellowship to do graduate work in metallurgy. If things go as hoped, Bill believes he would like to aim for research and development work, and will eventually plan to enter administrative work associated with metallurgy.



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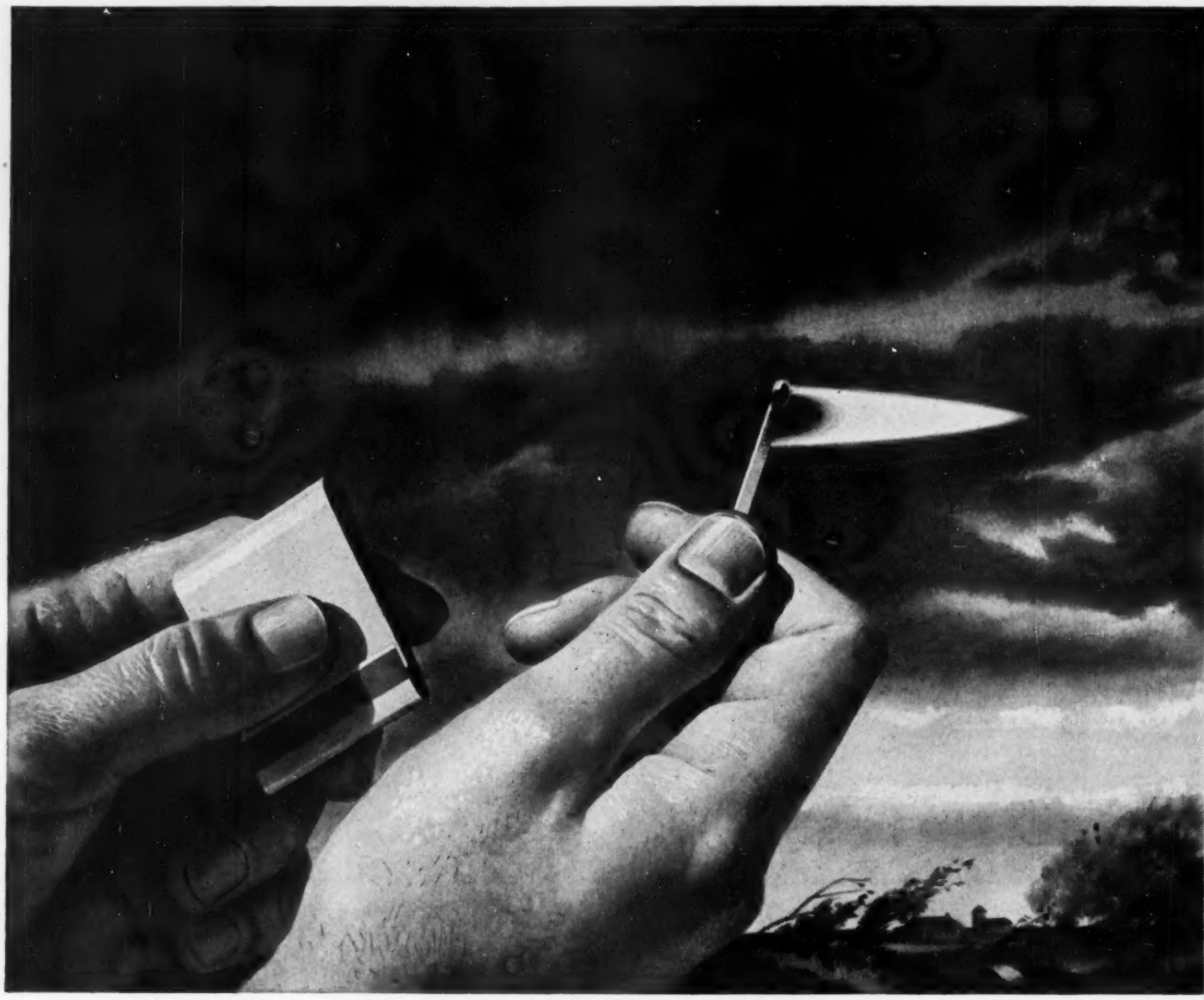

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Walter M. Bacon

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates, and former students and to establish closer relationship between the college and the alumni."

Labor, its leaders, and a few economists, have for many years predicted that the mechanization (now being called automation) of industry and public service would result in fewer jobs being available and cause widespread unemployment. The tremendous strides now being made in the field of automation have intensified these fears and considerable opposition to further mechanization is being expressed. In the past the years of unemployment due to automation have proved groundless. In those countries where the mechanization of industry was prevented because of the pressure of labor organizations economic disaster in the industries affected has resulted. There have been and most likely will continue to be periods of adjustment with a temporary oversupply of certain types of labor in certain geographical areas. Even with the expected accelerated trend toward automation in the future the fear that it will cause widespread unemployment will in all probability again prove groundless.

In the opinion of a number of today's economists there will be, in spite of increased automation, a definite labor shortage during the next twenty years. Several things will contribute to this shortage. One of these is the trend toward shorter hours, increased vacation periods, and additional holidays. Another is a decrease in the average number of years worked by an individual due to extended education before starting to work and due to earlier retirement. This will increase the proportion of non-productive people to productive people and the latter will have to produce more. While these reasons will have a definite effect the major reason given for a future labor shortage is the accelerated increase in population. Each year shows an increase in the number of children born (over 4,000,000 in 1954) and there is every reason to believe that this figure will continue to get larger. It is estimated that while the total population of this country will increase by at least two-fifths in the next twenty years, the working population will increase by less than a third and this in conjunction with the other reasons given above will result in an effective increase in the working population of only one-fifth or half the increase in total population. This, of course, means that every worker will have to produce considerably more than he is now producing in order to provide the food, clothing, housing, and other needs of the greatly increased non-working population.

If these opinions and beliefs are realistic there seems to be no need to fear unemployment due to automation. They do, however, point to a necessity for increased automation in order to prevent a real labor shortage.

W. M. BACON

In Memoriam . . .

Hannibal Choate Ford

Mr. Hannibal Choate Ford, founder of the Ford Instrument Company, and inventor of the first mechanical brain for controlling gunfire, died at 10 p.m. Saturday, March 12 at his 11-acre estate at 233 Kings Point Road, Kings Point, Long Island. He would have been 78 on May 8th.

Mr. Ford held more than 50 U.S. patents for inventions that revolutionized modern warfare and led to the design of present-day gunfire computers and modern bombsights.

But Ford's work, mainly for the military, often was "top-secret." So public fame that might have been his was denied him.

In 1926 Mr. Ford developed an anti-aircraft computer with 55,000 moving parts, which enabled a ship to down an airplane. Two years ago Admiral Oscar C. Badger, U. S. N. (retired) called it "one of the most incredible pieces of machine design in modern times."

Computers used in World War II essentially were electronic refinements of this computer.

Ford was an inveterate tinkerer, an intensive worker who has been known to solve problems with a slide rule while driving an automobile. He used to draw designs on his hands whenever he had a sudden idea and had no paper handy.

On the lawn of his Kings Point, Long Island home overlooking the sea is a giant bronze eagle equipped with a mechanism which permits the bird to revolve to face an approaching boat. Ford has wired it so he can, at the touch of a button, turn on a record of authentic eagle screams.

In his home he built and installed an elaborate workshop, and such items as swinging panels in the study, electric window openers, special lighting in the billiard room,

Hannibal Choate Ford

and pre-deep freeze refrigeration equipment. In his summer home in the Catskills at Olivebridge he designed and later had installed a spiral elevator leading up to the top of a tower.

He was born at Dryden, N. Y., May 8, 1877, the son of Abram Millard and Susan Augusta (Giles) Ford. His father was for many years editor and owner of the Dryden, N. Y. Herald, a weekly newspaper.

In 1899 he entered Cornell University and graduated as an electrical engineer four years later. While at Cornell he worked as mechanician in the electrical engineering laboratory of Sibley College.

Later he worked on the Hudson Tunnel and the Manila (P.I.) tramways as an employee of the New York City engineering firm of J. G. White and Co. From 1906 to 1909 he worked for the Smith-Premier Typewriter Co., during which time a number of patents were issued to his credit.

In 1909 Ford assisted Elmer A. Sperry in development of the Sperry gyroscope. When the Sperry Gyroscope Company was set up in 1910 Ford was its chief engineer. He resigned in 1915 to organize the Ford Marine Appliance Corporation with a capital of $50,000. Ford held the position of vice president and general manager.

A year later the firm was reorganized as the Ford Instrument Company with a capital of $100,000. In 1930 Ford became its president. Starting with about 50 employees, the company grew to more than 8,000 in World War II.

Among the more important of his early patents were two, issued in 1906, covering a system of speed control for railways where traffic is congested, as in the New York City subway system.

This invention made it possible to regulate the speed of a following train in accordance with the requirements of safety, depending on its position in respect to the preceding train.

A second group of patents, issued between 1908 and 1915, covers various improvements in typewriting machines and attachments thereto for business purposes.

The third and largest group, issued in 1918 and later, covers gyroscopic and navigational apparatus for ships and many types of instruments and intricate computing machines, such as the Ford range keeper (patented, March 1, 1921), largely used by the U. S. Government for control of gunfire.

Many other of his inventions, some of which were patented and the patents later withdrawn, are national defense secrets and may not be mentioned but they represent some of his most outstanding work.

In 1930 Mr. Ford organized the Merrill Aircraft Company and developed an experimental plane which was successfully demonstrat-

(Continued on page 55)

ALUMNI ENGINEERS

William L. Savacool, C.E. '04, 148-14 Eighty-fifth Drive, Jamaica, was honored by the Queens Chamber of Commerce for fifty years of "distinguished public and humanitarian service to the people of the County of Queens" during ceremonies at the Chamber's annual dinner at the Hotel Commodore in New York City. Among the many projects originated by Savacool during his twenty-eight years as chairman of the Borough Planning Committee of the Queens Chamber of Commerce were: Queens-Midtown Tunnel, LaGuardia and Idlewild airports, Triboro and Whitestone bridges, and parkways running through the borough. Savacool has also served as director and vice-president of the Queens Chamber of Commerce, director of the Park Association of New York City, and director of the Queens Botanical Society. He is married to the former Mary Eshbach of Ithaca (Ithaca College '06) and is the father of **Mary Savacool '36** (Mrs. John W. Saunders).

John N. Beckley, C.E. '07 has been named vice-president and Eastern district manager of The Austin Co., national engineering and construction firm. Beckley joined the company as an estimator in 1941 and was appointed acting district manager in 1945. He was assistant general sales manager for three years and has been a project engineer on important programs in the electrical, petroleum, and mining industries. He will have offices in both New York City at 600 Fifth Avenue, and in Roselle, N. J.

Raymond T. O'Keefe, Jr., M.E. '10 has been named President of the Chicago & West Towns Railway. He will also continue as general manager, a position he has held since joining the company on October 1, 1954. Mr. O'Keefe has been associated with transportation for many years. He served in an executive capacity with several railroads including the Chicago Transit Authority, Chicago Surface Lines, Philadelphia Subways and Elevated System, and the Seattle Transit Company. He is a member of the Western Society of Engineers, the Institute of Traffic Engineers, the American Transit Association, and the Union League Club of Chicago.

Oliver Buckley, E.E. '14 has been awarded the 1954 Edison Medal by the American Institute of Electrical Engineering. He is retired president of Bell Telephone Laboratories, Inc., and was given the award in recognition of his contributions to the development of the trans-Atlantic telephone cable and his service to the government. The medal, one of engineering's major awards, was presented February 2 at the Institute's winter meeting. Buckley is a member of the Engineering College Council, and lives at 13 Fairview Terrace, Maplewood, N. J.

(Continued on page 62)

High Temperature

(Continued from page 8)

turn means that we must understand what happens to air molecules at high temperatures, for that will determine the amount of heat transferred to the skin of the plane. The study of the thermal behavior of air of course will be far more complicated than that of argon, for we shall have to deal not simply with the stripping of an electron from the atom but with the dissociation of oxygen and nitrogen molecules, and the resulting formation of nitric oxide from the free atoms and with the ionization of a number of different molecules. Such studies are just beginning.

Now let us consider the electromagnetic aspect of the behavior of gases at very high temperatures. The outstanding fact is that at these temperatures a gas becomes a very good conductor of electricity, because the heat produces a large number of free electrons. Certain theoretical considerations indicated that the conductivity of any gas should rise with the rise in temperature to a limiting value which is independent of the chemical nature of the gas. This was confirmed by measurements with the shock tube. For example, argon at 15,000 degrees becomes so conductive that a current of 100 amperes per square centimeter will flow across one centimeter of the gas when the potential difference is only one volt.

—Mount Wilson and Palomar Observatory

Veil Nebula in Cygnus apparently represents a collision between interstellar gas and gas expelled by explosion of a supernova. The fine filaments are about 100,000 miles thick, suggesting shock waves moving through the rarefied instellar gas.

Because of its high conductivity, a filament of very hot gas behaves like a wire in an electric or magnetic field. This is spectacularly evident in an astronomical mass of hot gas such as the sun. For instance, during explosions on the surface of the sun it has been observed that prominences (tongues of hot gas) eruping from the sun's surface followed magnetic lines of force instead of simply following the pressure field, as an exploding gas on the earth would do. Stimulated by such observations, Hannes Alfven of the Swedish Royal Institute of Technology, G. K. Gatchelor of Cambridge University, Enrico Fermi and S. Chandrasekhar of the University of Chicago and others have begun the new study of magneto - hydrodynamics — how gases (and liquids) move under the influence of electromagnetic and pressure forces.

It is plain that an electric current will be generated in a highly conducting gas moving across the lines of a force of a magnetic field, just

THE ALUMINUM INDUSTRY WAS BORN ON SMALLMAN STREET

▼ In 1888, the aluminum industry consisted of one company—located in an unimpressive little building on the east side of Pittsburgh. It was called The Pittsburgh Reduction Company. The men of this company had real engineering abilities and viewed the work to be done with an imagineering eye. But they were much more than that. They were pioneers . . . leaders . . . men of vision.

A lot has happened since 1888. The country . . . the company . . . and the industry have grown up. Ten new territories have become states, for one thing. The total industry now employs more than 1,000,000 people—and the little outfit on Smallman Street? Well, it's a lot bigger, too—and the name has been changed to Alcoa. ALUMINUM COMPANY OF AMERICA . . . but it's still the leader—still the place for engineering "firsts".

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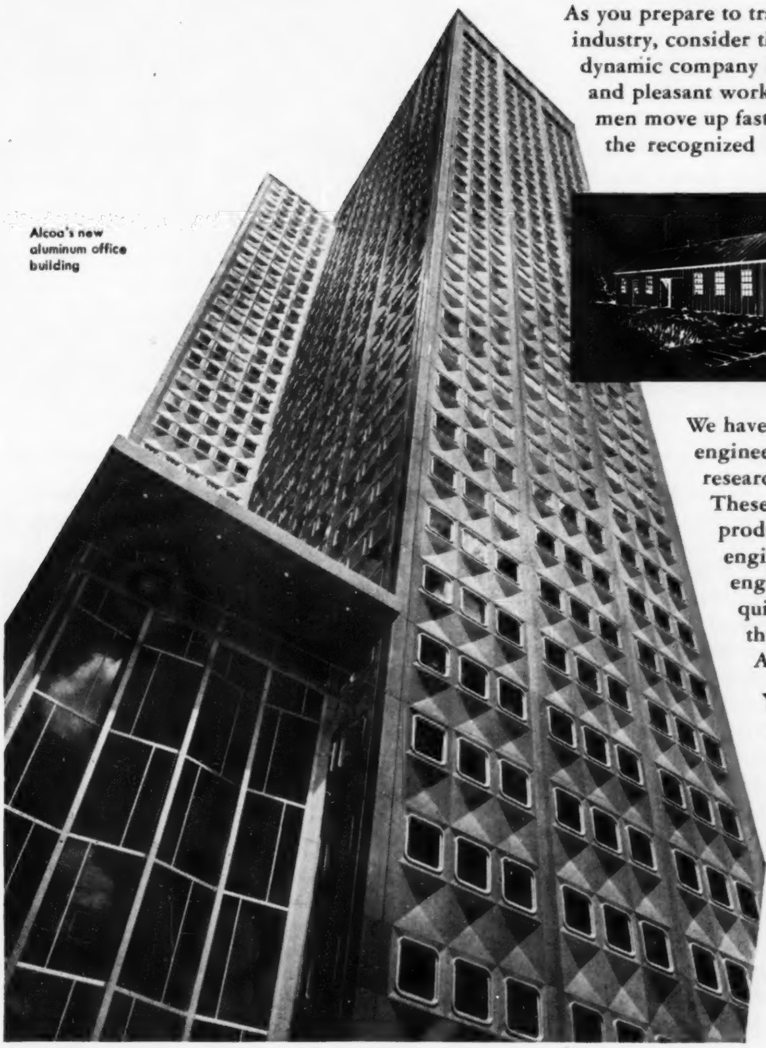

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as it is in the armature of an electric generator. On the other hand, an electric current in such a fluid will produce a magnetic field. Thus conducting fluids in nature may spontaneously generate magnetic fields. The magnetic field of the earth is probably created in this way by motions of its hot, fluid core. And natural magnetic fields on a much larger scale have recently been invoked to explain many phenomena in cosmology. For instance, Alfven and others have suggested that magnetic and electric fields in space may accelerate the cosmic rays. Chandrasekhar and Fermi have proposed that a weak magnetic field in our region of the Milky Way supplies most of the force that prevents our spiral arm of the galaxy from collapsing under gravity.

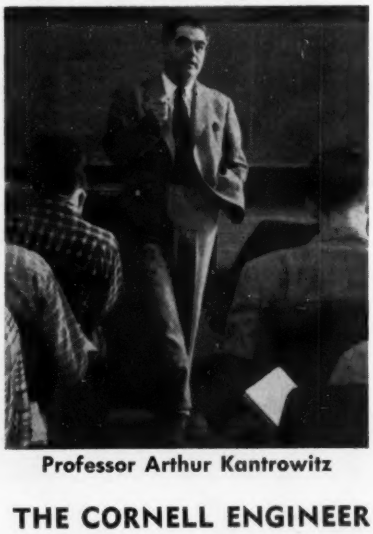
One of the most striking demonstrations of the play of high-energy gas dynamics in space is the recently discovered phenomenon of celestial radio waves. That these waves probably emanate from violent gas motions is indicated by several items of evidence. When the surface of the sun is quiet, it emits very little radio noise; but when it erupts, the disturbed area emits about a million times more radio energy. Some of the so-called radio stars—pin-pointed sources of radio energy—are located in regions of violent gas motion. One of them is the swirling cloud called the Crab nebula, which is the gaseous remains of a star that exploded 900 years ago. Another is a region where two galaxies are colliding; collisions between the gas clouds associated with galaxies should produce strong shock waves. The possible connection between shock waves and the mysterious celestial emission of radio energy is a promising subject for research.

Astronomers have been puzzled for some time by certain lines of luminosity that are found in the heavens. Some of these lines are believed to show regions where gas ejected from the exploding supernova has collided with clouds of gas in interstellar space. The Dutch astronomer J. H. Oort recently suggested that the lines of light may represent shock waves; he points out that their thickness (some 60 billion miles) is about the size of the region one would expect a shock front to cover in the thin interstellar gas. When Oort made his suggestion, no luminous shock front had ever been observed in a terrestrial explosion. But such a luminous line does appear in a shock tube where argon is accelerated to Mach 10. In further support of Oort's theory, the picture clearly shows that the most luminous region in the gas is the shock front itself, rather than behind the front, where we should expect the gas molecules to be hottest. The luminous shock front in the shock tube is still in some respects very puzzling, particularly the fact that a brief luminosity sometimes occurs

(Continued on page 56)

About the Author

"Very High Temperatures," written by Professor Arthur Kantrowitz, appeared in the September 1954 issue of the Scientific American. Professor Kantrowitz is a professor of aeronautical engineering at Cornell, and professor of engineering physics. Upon completing his graduate work at Columbia University, he worked as a physicist with the National Advisory Committee on Aeronautics from of 1935 to 1946. There he was in charge of the gas dynamics section, and was instrumental in the development of the supersonic axial flow compressor. Professor Kantrowitz was a lecturer at the Eighth International Congress of Theoretical and Applied Mechanics at Istanbul, and is a Fulbright scholar at Cambridge and Manchester Universities. In addition, he holds a Guggenheim fellowship.



Professor Arthur Kantrowitz

College News

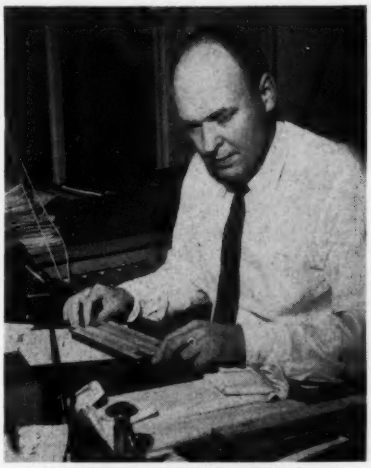
In the age of automation, with its electronic data-handling machines and high speed computers, industry will need a completely new kind of manager, according to Prof. Anderw Schultz Jr. of Cornell University. He compares the problems of the industrial manager of the future with those facing the naval line officer of World War II who found that "for all practical purposes the operation of his command was in the hands of a communications officers locked up in the control center."

Professor Schultz, head of the Department of Industrial and Engineering Administration in Cornell's Sibley School of Mechanical Engineering, discusses how to train these new managers in the March issue of *Armed Forces Management.*

Automation, he says, will convert most of the production and some complex machines with many elements and with resultant problems of planning, integration, and control." Modern electronic equipment, he adds, by doing computing that was not feasible before, will solve very complex problems of production, personnel, distribution and design, once the problem is stated in a mathematical, objective form.

"Just as the key operator in the plant of the future will be the highly skilled maintenance mechanic who will keep the process in operation," he writes, "the manager will be highly trained and skilled in dealing with the complex production and operating procedures."

Using the new methods will cut across present organizational lines and require major changes in the training and abilities needed in some individual positions in an organization. The solutions could be a series of staff or "assistant-to" positions filled by highly technically trained persons, but Professor Schultz doubts that "management which must blindly and ignorantly follow technical recommendations will long survive." Formerly an engineer's or manager's decisions could be tested in actual operation and corrected relatively cheaply, he adds. "In the future, the cost of an error will be much greater, and a greater effort to make correct decisions in the first place will be necessary.



Professor Andrew Schultz

The articles describes the Cornell department's program which began 50 years ago when the late Dean Dexter S. Kimball, foreseeing that engineers would become leaders of industry, started an elective course called "Yorks Administration." Administrative engineering students at Cornell receive a thorough training in engineering, and then take courses in industrial organization, statistics, methods engineering, cost accounting and control, and production engineering. The subject is not approached through a general business course with a smattering of engineering and science courses, and emphasis is on fundamental concepts rather than techniques. As elective course, students choose such new topics as linear programming, statistical control, experimental design, and courses in other divisions on campus—business and public administration, industrial and labor relations, psychology, sociology, economics.

Students specializing in industrial engineering spend most of their last year in Cornell's five-year course on an actual project suggested by industries, Professor Schultz explains. They work alone or in groups numbering from three to 18 on problems suggested by companies varying in size from 20 employees to 200,000.

Engineers' Day

In a very few days the engineering centers of the Cornell campus will throw open their doors to some four thousand students and visitors interested in the activities of the College of Egnineering. This annual event, Engineers' Day, to be held during the afternoon and evening of Friday, April 29, promises to be both enjoyable and enlightening.

On the program for E-Day will be displays and demonstrations prepared by students in the four schools of the College of Engineering (Chemical, Civil, Mechanical, and Electrical), the Department of Engineering Physics, and the College of Architecture. The displays—accurate samples of current projects, subjects of instruction, and methods of teaching, are to be located in the buildings occupied on campus by the participating schools, and engineering - student guides will be on hand to help guests find their ways about.

The Student Engineering Council, sponsor of Engineers' Day, will present an award to the school or group having the display judged best and most original. This award, together with several other en-

gineering prizes, will be announced at the Engineers' Banquet, also an annual event, Saturday evening. The E-Day trophy was received last year by the Civil Engineers, who had constructed an excellent model of the St. Lawrence Seaway Project. Last year's attractions included also demonstrations by the Cornell Rocket Society of the launching of a model rocket; displays at the E.P. department of basic research in such topics as transistors and electron microscopy, and the Cornell Syncroton in the Newman Laboratory of Nuclear Studies; and by the E.E.'s, a remarkable demonstration of the methods of binaural sound, using Glee Club. It is expected that the recordings made by the Cornell E.E.'s, inspired by Phillips Hall, their newly-completed building, will this year be strong contenders for the E-Day prize.

Engineers' Day is run in conjunction with (and is the larger part of) "Cornell Day," a weekend opportunity for prospective freshmen, under sponsership of various alumni groups, to see Cornell firsthand. The E-Day program, however, is not restricted to the four or five hundred sub-frosh expected to visit here, but is open to the public. This year, the Engineering Council has elected to set a new precedent for E-Day by scheduling the event for afternoon as well as evening hours, so that area high schools will be able to bring in bus-loads of interested students to attend the proceedings.

The E-Day program is directed in each school (and group) by students other than those who are members of the Engineering Council, so that the necessary interest and competition may be more widely distributed. The general chairman this year is John D. Baldeschwieler, Chem. E. '56. The school chairmen are: Chem. E., G. C. Cramer '55; E.E., Irwin M. Jacobs '56; M.E., Charles W. Simmons '56; C.E. Damon G. Douglas '56; E.P., Gordon L. Smith '56; and Arch., Andy J. Kaufman '56. The publicity manager is Joel Mallin, Chem. E., '56, program manager, Don R. Badgeley, M.E. '56, and banquet chairman, Ken Carlson, C.E. '54. Judging will be in charge of Leonard A. Mende, E.E. '55.

These people and the CORNELL ENGINEER, take pleasure in inviting you "up to the Hill" on April 29 to take part in Engineers' Day, with the assurance that you will find the experience well worth while.

Summer Course Given In Electron Microscopy

The Summer Laboratory Course in Techniques and Applications of the Electron Microscope will be given again this summer from June 13 to June 25, 1955, by Cornell's Laboratory of Electron Microscopy in the Department of Engineering Physics. The course, under the direction of Professor Benjamin M. Siegel, will have Professors Cecil E. Hall of M.I.T. and Robley C. Williams of the University of California as guest lecturers this year.

The course is designed to give members an intensive survey of basic theory and interpretation of results. The registration is limited to a small group so that ample facilities are available for each one to pursue laboratory work in his special field. Each may work at an introductory or advanced level depending on his previous experience. Further inquiries should be addressed to Professor Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, New York.

—Photo Science

Dr. Benjamin M. Siegal (left) and Dr. Lloyd P. Smith examine one of the electron microscopes in Cornell's Electron Microscope Laboratory."

The Cornell Society of Engineers: How Do We Fly From Here?

A group of seventy-five Cornell engineers was addressed recently at a meeting of the Cornell Society of Engineers by Mr. William Littlewood, M.E. '20, president of the Society of Aeronautical Engineers, and vice-president of American Airlines, Inc. Mr. Littlewood's topic was concerned with the future of the trends in modern aeronautical sciences, air transportation, and military aircraft applications.

Littlewood has long been a memation field date back to 1927, when he joined the Fairchild Engine and Airplane Company as production manager. In 1930, he moved to American Airways, Inc., which became American Airlines, Inc., in 1934.

He was born in New York City in 1898 and attended Long Island Public Schools. He went to Cornell University, graduating in 1920 with a degree in Mechanical Engineering. While a student at Cornell, he received the Sibley Prize, a symbol of the highest rating in engineering studies for two consecutive years.

Littlewood has long been a member of the National Advisory Committee for Aeronautics, having served as chairman of that group's important Committee on Operating Problems. He has also been a member of the Aeronautics Committee of the Research and Development Board, and a consultant to the Air Research and Development Command.

Littlewood is a fellow and past vice-president of the Institute of the Aeronautical Sciences.

His contributions to SAE are well known. He was vice-president representing the Air Transport Activity in 1945, has been an SAE-designated director of the Coordinating Research Council, served as a member of the Aeronautics Division of the General Standards Committee from 1940 to 1944 and was chairman of the Aircraft & Equipment Sub-division during that period, and has held many other important posts.

As a Cornell Alumnus, Littlewood is a director of the Cornell Aeronautical Laboratories, has served several terms as director of the Cornell Alumni Association, and is past president of the Cornell Society of Engineers. Mr. Littlewood's headquarters, with American Airlines, are located in Washington, D. C.

The next meeting of the Cornell Society of Engineers, scheduled for

1922—Roll-out of a Boeing-built fighter

1954—Roll-out of America's first jet transport, the Boeing 707

Progress is a Boeing-career hallmark

From the earliest days of aviation, Boeing engineers have produced an impressive number of trend-creating "firsts"—including the 707, America's first jet transport, shown above.

Boeing's 38-year history of Research, Design and Production progress has continuously opened up new career opportunities for engineers. Today Boeing employs more engineers than even at the peak of World War II.

At Boeing you'd work with engineers who developed: The world's first all-metal, 3-mile-a-minute commercial transport. The first pressurized airliner. The first effective four-engine bomber (the B-17). Today's fastest operational bomber (the six-jet B-47). The even more advanced B-52 eight-jet global bomber, and the 707, America's first jet transport. Boeing engineers continue to design "years ahead," doing research on nuclear-powered aircraft. They are also developing a new Air Force defense weapons system, based on the Boeing F-99 Bomarc pilotless interceptor. These long-range programs project Boeing progress far into the future.

One measure of the satisfaction of Boeing careers is given in the chart below. It shows that 46% of Boeing engineers have been with the company for five or more years; 25% for 10 or more years, and 6% for 15 or more years.

Here are other advantages: Boeing promotes from within and holds regular merit reviews to assure individual recognition. Engineers are encouraged to take graduate studies while working and are reimbursed for all tuition expense.

Of technical graduates at Boeing, 28% hold Mechanical Engineering degrees, 24% Electrical, 19% Aeronautical, and 9% Civil. The remainder is comprised of other engineering graduates, physicists and mathematicians.

For further Boeing career information consult your Placement Office, or write:

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Company, Seattle 14, Wash.

BOEING

SEATTLE, WASHINGTON   WICHITA, KANSAS

May 5, 1955, will be addressed by S. C. Hollister, Dean of the College of Engineering, Cornell University.

Silent Hoist & Crane Annual Essay Contest

April 25 is the deadline for submitting essays in Cornell's annual contest for Silent Hoist and Crane Company Materials Handling Prizes of $125, $75 and $50.

The Wunsch Foundation, Inc., established the prize fund in 1950. Awards are for the best three papers on materials handling, and any student in the College of Engineering at Cornell may compete.

Profs. R. L. Geer, John C. Gebhard and Robert L. Von Berg form this year's judging committee. Papers should be submitted to one of the committee.

Graduate Scholarship

A graduate scholarship for soil moisture research has been established in the Cornell School of Civil Engineering by Armco Drainage and Metal Products, Inc., of Middletown, Ohio.

The scholarship offers $2,500 a year for a one-year or two-year program, beginning with the spring term in February. It will include tuition, a stipend, and funds for field tests.

The recipient will also have the use of the school's equipment for measuring soil moisture and density by neutron and gamma ray scattering principles.

Information may be obtained from Prof. D. J. Belcher, head of the Department of Transportation, School of Civil Engineering, Cornell University.

Thurston Exhibit

Engineering and manufacturing activities of the Proctor & Gamble Co., were featured in a special exhibit at Thurston-Kimball Hall last month.

Built by personnel of Procter & Gamble's Engineering Division, the display: (1) depicted with schematic flow charts, photographs, actual samples of the products and other means the manufacturing processes involved in making certain P&G products, and (2) featured typical functions of the metallurgical and construction departments of the P&G engineering division.

Civil Service Positions

Students in the fields of engineering and the physical sciences may be interested in the Student Aid Trainee examination which has been announced by the U.S. Civil Service Commission for filling positions in various establishments of the Potomac River Naval Command in Washington, D.C., and vicinity. These positions, which pay from $2,750 to $3,175 a year, are for employment during the school vacation periods and during the periods for employment of students in cooperative courses.

To qualify, applicants must pass a written test and have completed courses of study in an appropriate field. Full details concerning the requirements to be met are given in Announcement No. 4-34-1 (53), which may be obtained from the school placement office.

Applications will be accepted until further notice and must be filed with the Board of U.S. Civil Service Examiners for Scientific and Technical Personnel of the Potomac River Naval Command, Building 37, Naval Research Laboratory, Washington 25, D.C. Application forms may be obtained from your placement office, from most post offices, or directly from the U.S. Civil Service Commission, Washington 25, D.C.

Lyon Speaks Before Sigma Xi

Lt. Col. David R. Lyon of the Cornell ROTC unit discussed "Developments in Electronics and Guided Missiles in the Armed Forces" at an open meeting of Sigma Xi on Tuesday (Feb. 8).

A film from White Sands, illustrating the talk, included unusual photographs of the earth and sky as they appear from a rocket 76 miles high.

Colonel Lyon also discussed problems of maintaining and operating electronically controlled equipment, with its increasing complexity and capability.

The officer served with various artillery units in World War II, was on the staff of the Artillery School at Fort Sill and taught and did research on communications and electronics as used by artillery.

In the Far East, when hostilities began in Korea, he served with the 24th Infantry Division as a communications officer and unit commander. Reassigned to the Theatre's general staff in Tokyo, he served under Generals MacArthur, Ridgeway and Clark, and, then, joined the Cornell unit in 1952.

Prof. Meserve at Sidney

Prof. Wilbur E. Meserve of Cornell's School of Electrical Engineering is lecturing on servomechanisms at the University of Sidney and New South Wales University of Technology in Sydney, Australia, from February to September 1955, under a Fulbright grant.

Professor Meserve is a graduate of the University of Maine and taught there before coming to Cornell in 1926. Included in his industrial experience is research on mercury-arc rectifiers for Brown-Boveri Company. Professor Meserve is a member of the American Institute of Electrical Engineers and has contributed to numerous technical journals.

Speaker on British Aviation

Captain J. Laurence Pritchard, a pioneer in British aviation, spoke in Olin Hall on Thursday, Feb. 10. His illustrated lecture, "From Gas Balloons to Gas Turbines," was open to the public and quite informative.

Captain Pritchard began writing about aeronautical problems in 1909, the year the Wright brothers first visited England and two years after he received an honors degree in mathematics from Cambridge.

During World War I he was in the Royal Naval Air Service and in 1919 he became editor of the Journal of the Royal Aeornautical Society and a member of its council.

He was secretary of the society from 1925 until 1951, and also helped to establish the Institute of Aeronautical Sciences in the United States, working closely with Cornell's Vice President T. P. Wright and others.

He is co-author of "Aeroplane Structures" (1922), the first English language textbook on airplane structural analysis. He has written numerous articles in this field and is working on a history of the Royal Aeronautical Society.

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a Few Years Make at MARTIN!

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Technibriefs

As aircraft and missile speeds become greater, the problems of the aeronautical engineer become manifold.

The design of wind tunnels for testing models at speeds faster than sound and the prevention of "flutter" in high speed airplane and missile wings and tail surfaces are but two of countless difficult problems that must be solved if the United States is to maintain its lead in aircraft development.

These two problems are discussed in the current issue of RESEARCH TRENDS, quarterly publication of Cornell Aeronautical Laboratory, Inc.

King D. Bird in an article titled "Wind Tunnels Have Walls" points out that even before the Wright brothers' first flight the first low speed wind tunnels were built.

"The modern high speed wind tunnel is a far cry from its primitive ancestor with regard to size and complexity; yet its basic role is still to provide a controlled stream of air in which a scale model may be placed."

"The validity of tests run in a wind tunnel depends on the principle that moving air past a stationary model yields the same forces as those that would act on a model if it were moved through the air as in actual free flight. Missiles and airplanes can be effectively engineered only if accurate data are available."

When the air moves past the model a shock wave is created which is reflected from the wind tunnel walls back onto the model. The effects of these wall reflections have no counterpart in actual flight, thereby invalidating the test data. This is particularly true during transonic testing, the author reported.

The Cornell Laboratory, in its approach to the wave cancellation problem, reasoned that the use of a porous or perforated wall in wind tunnels would result in alternate shock and expansion waves being reflected from the walls. These waves, being of opposite character, merge and self-cancel close to the wall, reducing reflections back onto the model.

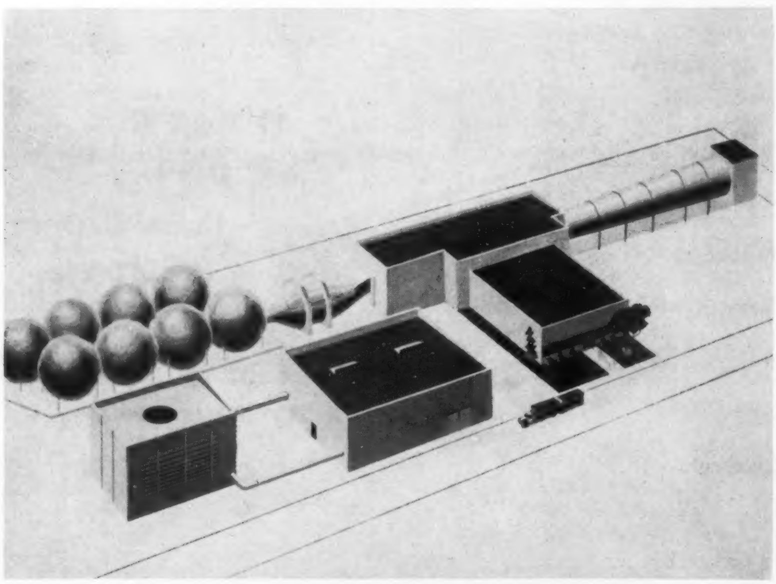
Following successful experiments, a 4-foot perforated transonic throat was made to fit the Laboratory's 12-foot Variable Density Wind Tunnel, and it has been operating successfully for two years.

Walter P. Targoff in his article on "Flutter" states that under certain adverse design and speed conditions a self-magnifying oscillation arises in wings and tail surfaces. After a short time these oscillations can become dangerously large and the "flutter" may lead to structural failure.

Flutter is very often of an explosive character and the transition from normal flight to violent, destructive oscillations may occur in less than one second. Despite the most painstaking care in the approach to the critical speed, after the onset of flutter an airplane is very likely to be completely destroyed before its speed can be reduced to a safe value. Even under the controlled conditions of wind tunnel testing, such as that done at Cornell Laboratory, it is very frequently impossible to prevent flutter models from oscillating to destruction.

Mr. Targoff says that the growth of theoretical background is being outstripped by the rapidly advancing speed frontier. He concluded that a true solution to the many present and future design problems cannot be obtained until a sound theoretical understanding is available of unsteady aerodynamic characteristics of high speed aircraft with low aspect ratio (that is, stubby) wing and tail shapes. Typical of this stubby design in advanced aircraft are the delta and sweptback types.

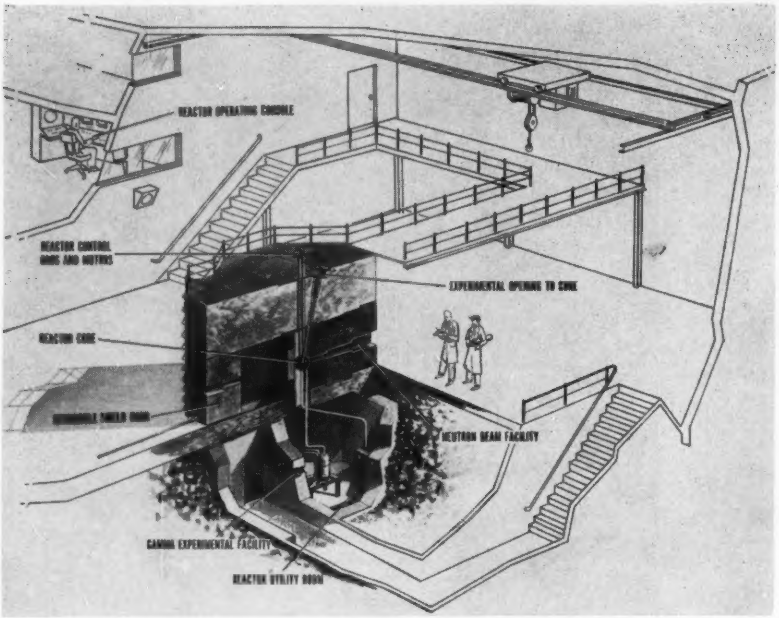
Model of the twelve-foot Variable Density Wind Tunnel at the Cornell Aeronautic Laboratory.



Reactor for Industrial Research

The first nuclear reactor specifically for industrial research will be constructed this year at Armour Research Foundation of Illinois Institute of Technology, Chicago, after approval by the Atomic Energy Commission.

North American Aviation, Dow-



Model of the first nuclear reactor for industrial research to be constructed this year at Armour Research Foundation of Illinois Institute of Technology in Chicago.

ney, Calif., has been awarded the contract to build the reactor. Construction is scheduled to begin about March 15, with completion scheduled by the end of the year.

Midwestern industries will join the Foundation in financing the reactor and associated equipment, which will cost approximately $500,000. The reactor will be part of a new research building to be located on Chicago's south side.

Armour Research Foundation is a non-profit organization established in 1936 to serve the research needs of industry, government, and the general public. Established without endowment as an independently incorporated part of Illinois Institute of Technology, the Foundation is supported solely by revenue from its research contracts. It has more than 1,100 staff members.

The Foundation is divided into nine departments containing about 60 sections. The departments are Ceramics and Minerals, Chemistry and Chemical Engineering, Electrical Engineering, Heat - Power, Mechanism and Dynamics, Metals, Physics, Propulsion and Structures, and International. The nuclear reactor will be under the supervision of the nuclear physics section in the Physics Research department.

Improved Friction Testing Machine

Link Engineering Company of Detroit, Mich., and T. P. Chase, designer of the Chase Friction Materials Test Machine, have announced the design and development of a new machine for friction testing of materials under load, such as brake linings, that embodies several new concepts in testing and machine design.

The design of the machine is based on the fact that if a loaded sample of the material to be tested is held and made to ride on the rim of a revolving drum, at a point on the vertical center line, a horizontal friction force tangent to the drum surface will result.

Because this horizontal frictional force is approzimately the same at all speeds, a variable speed-constant torque power unit must be used to power the drum through all speeds and loading conditions desirable to test the material. The revolving drum is mounted on the end of a shaft that is mounted in self-aligning ball bearings. Between these bearings is a flywheel driven by two 'V' belts. Maximum full speed of the shaft is a little more than 900 R.P.M.

One of the important features of the new machine is a restraining device that has the ability to maintain position of the test sample on the verticle centerline of the drum regardless of any variation of the frictional force. This restraining device, pressure sensitive, measures and makes a continuous record of the characteristics of the material when subjected to any desired condition of operation.

Another important feature of this new method of applying load and transmitting friction force to a measuring device, is that the position of the loading unit is entirely controlled in the friction force line of action by the recording of the recording unit itself. The loading unit is kept within the plane of rotation of the force by two ball end links which are perpendicular to the line of force. This arrangement insures that there are no losses to be considered that would affect the recorded friction force.

Since the heat resulting from the work done by such a small test piece of friction material is not always sufficient to raise the temperature of the drum to that comparable in brake service, electric heating elements have been installed in a housing surrounding the drum. Thermocouples are installed in the drum and lining with current collector rings made of thermocouple materials on the drum hub to provide for indication of the operating temperatures of drum and lining. Records of these temperatures are kept automatically.

Blast Simulator Developed

The largest laboratory device yet developed for simulating the blasts from bombs has been designed at Armour Research Foundation of Illinois Institute of Technology, Chicago.

The instrument—called a "shock tube"—allows engineers to study the effects of blasts without actually exploding a bomb.

The new shock tube, which has a diameter of six feet, is considerably larger than any others developed in the country, according to the Foundation's propulsion and structural research department.

The new tube's significance lies in the fact that it enables scientists to study blast effects on larger-scale models of buildings which

(Continued on page 56)

Carrier Systems

(Continued from page 14)

the modulated carrier wave; these are the principal components. The carrier frequency is therefore suppressed by this arrangement.

In most transmission usage, a band-pass filter is used to suppress all of the above components except one of the side-bands, which is transmitted. A circuit identical to that of Fig. 7 is used at the receiving end for demodulation. The two voltages applied are now the carrier voltage and the incoming side-band. If the lower side-band were transmitted, the signal frequency applied to the demodulator could be represented by Kcos (C-Vt). Substitution of this expression in place of AsinVt in equation (10) will change the first term inside the brackets in equation (11) to

$$\cos[C-(C-V)]t=\cos Vt.$$

A suitable low-pass filter will eliminate the other demodulation components and thus produce the desired voice signal.

In broad-band carrier systems, the varistors are connected as in Fig. 10. The operation of this circuit is approximated by the two circuits of Fig. 11: by the first during the positive half of the carrier wave; by the second during the negative half. This circuit thus approximates a reversing switch.

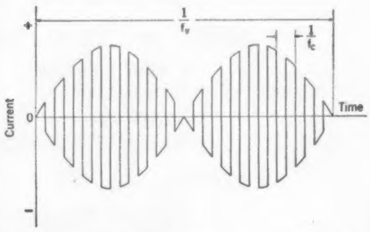


Figure 12. Output Current of Lattice Modulator.

The output wave in the ideal case is shown in Fig. 12. The approximate equation for this is as follows:

$$I = \frac{2A}{\pi(R_1+R_2)}\Big[\cos(C-V)t - \cos(C+V)t + 1/3\cos(3C-V)t - 1/3\cos(3C+V)t + 1/5\cos(5C-V)t - 1/5\cos(5C+V)t + \ldots\Big] \qquad (12)$$

Thus the lattice modulator circuit suppresses both the carrier and voice frequencies. Futhermore, the side-bands have twice the amplitude of those produced by the balanced bridge circuit, as a comparison with equation (11) will show. This circuit's inherent advantages of large side-band output and fewer unwanted products are very important in group modulators, which transmit a wide-band. Demodulation is accomplished by an identical circuit, with the same advantages.

In practice, varistors do not function exactly as Figs. 8 and 11 indicate; they are not infinite-resistance devices in one direction and zero-resistance devices in the other, and the transition from high to low resistance (Fig. 6) is gradual, not sharp. Furthermore, exact bridge balance can only be approximated in practice.

A new method of modulation, which has not found much application in telephone systems up to this time, is pulse modulation. In this method, the voice signal is converted into energy pulses for transmission. Translation of these signals at the receiving end into the original voice signal is possible if at least two instantaneous amplitude samples are taken for each cycle of the highest frequency in the signal wave. This method of transmission permits minimization of interference and reduces power consumption at the transmitter. It also allows several signals to be transmitted over a single carrier by

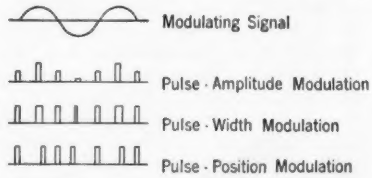


Figure 13. Pulse Modulation Methods.

using the intervals between the pulses of one signal to transmit those of another signal.

Three of the possible methods of pulse-modulation are illustrated in Fig. 13. Pulse-amplitude modulation employs pulses of equal time duration, having amplitudes varying with that of the signal wave. Both pulse-width modulation and pulse-position modulation employ pulses of constant amplitude. In the first method, the pulse duration is proportional to the signal amplitude; in the second method, the

(Continued on page 56)

Steel

(Continued from page 22)

and steel producing district soon declined and the Calumet area became the important iron and steel producing area. By the turn of the nineteenth century, the Calumet area had made a name for itself in the iron and steel industry, and the next few years would see even greater developments.

Location Favors Birmingham Industry

The Birmingham area development started about 1880. The favorable locations of coal for coke, iron ore, and limestone, all within a radius of a few miles, led to a rapid expansion. By the turn of the century Birmingham was a major producing center. As in the case of the Calumet area, a significant future lay ahead for Birmingham.

Future Holds Potential for Continued Progress

By the opening of the twentieth century, the major changes and developments of the iron and steel industry had all been made, with the exception of the invention of the electric furnace. With its electric arc heat source, the electric furnace can be regulated more easily than other types of furnaces and thus can be used to produce very high grade steels and alloys. The twentieth century has seen greater and more varied uses of iron and steel in industry and increased production of iron and steel rather than great changes in methods or the opening of new steel producing areas.

No one can say what changes the future will bring, but whatever they may be, we can be sure that the production of steel will continue to play an increasingly important part in our daily lives.

Bibliography:

Steel Making in America by Douglas A. Fisher. Published by the United States Steel Corporation in 1949.

The First Iron Works Restoration, a revision of the pamphlet "The Saugus Restoration." Published in 1953 by the First Iron Works Association in cooperation with the American Iron and Steel Institute.

Series of articles from "Steel Facts" between February, 1940 and April, 1947.

Ford

(Continued from page 36)

ed at North Beach airport (later LaGuardia field), N. Y. City, novel features of inherent stability.

He became President and Director of the Rawnell Holding Company, a real estate concern of Jamaica, N. Y., and a Director and organizer of the Jamaica National Bank. At its observance of the 150th Anniversary of the founding of the U. S. patent system, the National Association of Manufacturers in February 1940 presented him with a Modern Pioneer award (scroll).

Mr. Ford retired from active work at the Ford Instrument Company in 1943.

He was a life member of the American Institute of Electrical Engineers and the Army and Navy Country Club, Washington, D. C., of which he was a founder, and a member of the American Society of Naval Engineers, Sigma Xi and the Engineers' Club of N. Y. City.

In politics he was an independent Republican. He had a natural love for music and a special aptitude for mechanics, the latter cultivated assiduously from early childhood. He played the flute at school and college and in the Kittanning (Pa.) Symphony orchestra. His chief hobby was hand work in nearly all the mechanical arts, and he is maintained private workshops in his winter and summer homes.

A recent hobby was genealogy. He set out to trace the history of the Ford's (and related branches) in America and had a card file of 40,000 relatives.

In 1953 The Hannibal C. Ford Fellowship was established by the Ford Instrument Company to honor Mr. Ford, member of the class of 1903 at Cornell University. The Fellowship, set up on the 50th anniversary of Mr. Ford's graduation, provides $4,000 for a year's study at the graduate school of Cornell.

His only survivor is the former Katherine Moyer, daughter of James Eldredge, of Sharon Springs, N. Y., whom he married at Olivebridge, N. Y., July 4, 1918.

Typical of Ford's philosophy of life was the motto published in the Cornell Yearbook the year of his graduation:

"I would construct a machine to do any old thing in any old way."

Carrier Systems

(Continued from page 54)

pulse position is proportional to the signal amplitude. These latter two methods, employing constant amplitude pulses, allow the use of limiting circuits at the receiving end and non-linear amplifiers.

Bell Telephone Laboratories and the engineering branches of the widespread Bell System are constantly perfecting modern methods and inventing new methods in the science of telephony. At the present time, the Laboratories are working on a system of pulse-code modulation which will transmit a voice signal by means of what may be approximated by an automatic teletypewriter system.

Technibriefs

(Continued from page 52)

might be exposed to blasts.

The tube, which has been constructed in Gary, Ind., for the Air Force, has an over-all length of 150 feet. It already has been tested and is being put into use for model testing.

In order to get different shock wave pressures and durations, the tube was provided with interchangeable sections of varying lengths.

To absorb the maximum recoil force of 600,000 pounds, the foundation of the tube was designed as a slab of reinforced concrete ten feet wide, three to four feet thick, and 100 feet long with keys ten feet wide and six feet deep spaced twenty feet apart.

A certain amount of combustible gas is introduced into one section of the tube and is confined by a light diaphragm. The diaphragm is shattered when the gas is ignited, and the released pressure wave travels down the tube to the test section, where a building model has been placed. The resulting forces are recorded with electronic equipment.

Development of shock tubes stems from the fact that actual bomb tests are expensive, and it also is difficult to control the conditions under which they are conducted. Laboratory tests can be performed much more efficiently and over a much wider range of target items.

(Continued on page 62)

High Temperature

(Continued from page 40)

immediately, before the incubation period. A considerable body of evidence indicates that a shock wave may push a thin, concentrated layer of ions through the gas in which it propagates, somewhat in the manner of breakers propelling driftwood on a beach. The electrons accompanyings these ions would be heated by friction with the gas, thus producing the luminous region just ahead of the shock.

The investigation of the dynamics of very hot gases not only is beginning to unravel many mysteries of our astronomical cosmos but also offers some exciting possibilities in the technology of flight. Our present airplanes—rocket or jet-propelled—are ultimately limited in speed by the gas velocity that can be attained by chemical reactions. For practical space flight we shall need much higher velocities. One possible way to attain it is to accelerate gas with magnetic forces instead of merely with chemical combustion. There is no known theoretical limit to the propulsive impulse obtainable from a given mass of gas expelled in this way. The electrical energy for acceleration could be supplied by a nuclear reactor. This propulsion device would be essentially an electric motor with a gas replacing the usual solid armature.

It may even be possible to find ways to use magneto-hydrodynamic forces for control and lift, as well as for propulsion, of the ships in which man eventually will take off into space.

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37. Nice, D. R.
38. Patel, D. N.

A WHIRLPOOL SPIRALS into the inlet of a model pump. This unique picture shows how air, a common cause of pumping trouble, was carried into the pump in . . .

Technibriefs

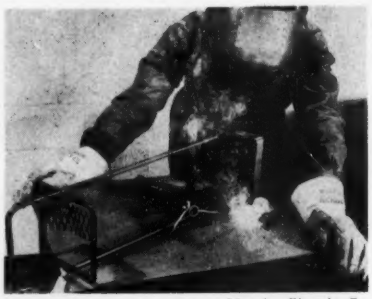
(Continued from page 56)

Beginners Weld By New Method

A new method of welding that eliminates skills normally required, and claimed to be as easy as turning on a light switch, promises to make it possible for the rapidly growing number of home fixit-yourself and hobby craftsmen to work with metals as readily as with wood. It is expected that the method will also be useful to business and service establishments such as bakeries, hotels, bottling plants, hospitals, body shops, repair shops and other users of metal equipment and machinery that occasionally need a quick, easy method of repair or maintenance fabrication.

The Lincoln Electric Company of Cleveland, Ohio, has developed the new method, called Selfweld, to create a quick, fool-proof method, usable by everyone, of joining metals for repairing and making such things as metal furniture, household and business equipment, tools, toys and automobiles.

Selfwelding is said to eliminate the difficulties that would be encountered normally by the amateur in learning the skill of manipulating the welding electrode and controlling the arc. The new method employs a special welding electrode and special electrode holder. To make a weld, the tip of the electrode is simply held against the metals to be joined at the point where the weld begins, a switch on the holder is pressed to fire the electrode, and the electrode, as the tip is held against the metal, automatically makes the weld itself. The electrode and holder normally do the work required of the person welding. Locating the beginning of the weld, starting the arc, feeding the electrode, the electrode angle and the travel speed are controlled automatically by the design of the electrode and holder. A supporting leg on the holder can be used to help locate and steady the electrode on the joint and to control the angle of the electrode. The coating of the electrode touches the work at all times so that the arc length is automatically determined. The meltoff rate automatically controls welding speed. Excellent welds are made on the first try, it is claimed.



—Lincoln Electric Co.

New Welding Method.

Oak Ridge Reactor School Now Accepting Applications

Applications for enrollment in the 1955-1956 session of the Oak Ridge School of Reactor Technology (ORSORT) are now being accepted. Enrollments for the 50-week course which begins in September will close on March 14, 1955. The School is a part of Oak Ridge National Laboratory, which is operated for the Atomic Energy Commission by Union Carbide and Carbon Corporation.

Industrial organizations may enroll a limited number of their technical personnel in ORSORT. The Atomic Energy Commission, aware of the growing need for competent nuclear reactor engineers, has made this participation possible to encourage nuclear progress in industry. The tuition is $2,500 for students from industrial firms other than A.E.C. operating contractors.

Students who are accepted will have the opportunity of participating in a curriculum of an advanced type, including courses covering classified details of reactor technology. Nowhere else can nuclear engineering students work on the variety of full-scale working reactors and other large units of equipment that are available for use in ORSORT courses.

Many leading industrial firms, realizing the future possibilities of atomic energy, have sent students to past courses at ORSORT. Fifty-two members of the present class are industry - sponsored students who will return to their own organizations at the end of the training period in August, 1955.

Additional information on Oak Ridge School of Reactor Technology, including the school bulletin and the necessary application forms may be obtained from: The Director, Oak Ridge School of Reactor Technology, Post Office Box P, Oak Ridge, Tennessee.

"Noise-free" Light Bulbs

Development of "noise-free" light bulbs for use in television broadcast studios and in motion picture studios is expected to improve noticeably the audio portion of TV programs on home receivers, and of sound movies in theaters.

Most people are not aware that light bulbs produce sound as well as light, since the sound is so low as to be inaudible on the low-wattage bulbs of the type used around the house.

However, TV and movie studios require great quantities of light, and use many high wattage lamps. In these lamps the noise is considerably greater. In addition, the sound is amplified by the metal reflectors used to concentrate the light.

In TV and small movie studios, the microphone boom must often be moved close to the lamps, where the noise is picked up. It reaches the ears of the listener in the form of a hum.

Alumni News

(Continued from page 37)

Harold S. Woodward, M.C.E. '23, Erik B. J. Roos, M.E. '32, and Stephen D. Teetor B.C.E. '43, were all admitted to the partnership of Seelye Stevenson Value & Knecht on January 1, 1955. The Consulting Engineering firm has its offices located at 101 Park Avenue, New York, New York and 1711 Connecticut Avenue, Washington, D. C.

Vincent Gerbereux, M.E. '24 has been chosen as General Manager of Worthington Corporation's Standard Pumps Division at Harrison, New Jersey. Mr. Gerbereux, who has been with Worthington since 1924, has been Manager of the Centrifugal Pump Division of the General Sales Department since 1951.

Commander **B. Otto Roessler, C.E. '31,** (CEC), USN, is public works officer and resident officer in charge of construction at the Naval Training Center at Bainbridge, Md. His daughter Kay is a senior and his son Dick is a freshman in high school. Address: Qtrs. O, U.S.N.T.C., Bainbridge, Md.

STRESS and STRAIN...

Once upon a time there lived in the South a man who worked all day in a stove factory, making stoves. He was, in fact, a stover, i.e., one who stoves. Now, this stover's boss not only ran the stove factory, but also (this was in pre-Civil War days) picked up loose change by trading in the slave market. He kept his spare slaves in the basement of the stove factory, right under where the stover worked.

One day the boss brought in a slave who was sick—had a high temperature (106° F) and was delirious. The slave kept shouting and ranting all day, which made it very hard for the stover to work. So when he, the stover, went home that night, his wife said, "My dear, you look tired."

"So would you look tired," he replied, "if you had been stoving over a hot slave all day."

* * *

I used to eat Wheaties for breakfast every morning. I'd split open the top of the package with a bread knife, sprinkle a quantity of the cereal in an ordinary oatmeal dish, pour in just enough cream, and coat the mixture with some plain white sugar. It wasn't so bad when grasping the edge of the bed to pull myself out mornings I'd tear it to bits under me. I didn't mind particularly when the steering wheel of my car crumpled under my hands and we turned over three times into the ditch. I thought it was a good joke when I banged the door of my fraternity house and it fell to the ground. But when I tried to kiss the only girl I ever loved and broke her neck, I went back to Grapenuts.

* * *

Engineer's Test for Good Whiskey—Connect 20,000 volts across a pint. If the current jumps it, the product was poor. If it causes a precipitation of lye, arsenic, iron, slag, and alum, the whiskey was fair. But if the whiskey chases the current back into the generator, you've got good whiskey.

The girl was through with her bath and was just stepping onto the scales to weigh herself. Her husband happened to return home at this time and entered through the back door. Seeing what his wife was doing as he pased the bathroom door, he exclaimed, "Well, dear, how many pounds today?" Without turning her head, she replied, "I'll take 50 pounds today, and don't you dare pinch me with those tongs."

* * *

"Those in the habit of putting buttons in the collection plate will please use their own buttons and not those from the cushions on the pews."

* * *

A woman asked a small boy, "Do you know how to swim?"

"Sure," replied the little boy, "when I get the notion."

"And when do you get the notion?" asked the woman.

"When I get in the water," replied the little boy.

* * *

A young man contemplating matrimony wanted to propose and didn't know how, so went to his dad for advice.

"Well, son," said the old man, "I don't know that I can help you much. With me and your Maw it happened one Sunday evening, when yer Maw and me was asittin' on the sofa. We was just a talkin' along and purty soon yer Maw leaned over and whispered in my ear and I said, "The hell you are,' and the next day we were married."

* * *

Engineering students are baffled by the fact that often the girls with the most streamlined shapes offer the most resistance.

* * *

Two indians had watched the building of a lighthouse on the rocky west coast with much interest. When it was finally completed they sat and watched it every night. A thick fog came rolling in one night and the siren blew continuously.

"Ugh," grunted one Indian to the other. "Light shine — bell ring — horn blow—but fog came in just the same."

* * *

Ship steward to seasick passenger: "Have a weak stomach, Sir?"

S.S.P.: "I'm throwing it as far as any of them, aint I?"

* * *

CAN YOU READ THIS?
Sevill dair dego
Tousin bussis inuro
Nojo demstrux
Sumit cousin
Sumit dux

* * *

A woman saw an elephant in her yard and immediately called the police.

"Chief," she said, "there's a queer-looking animal out in my back yard. He's picking flowers with his tail."

"Yes," said the sergeant, "and what does he do with them after he's picked them?"

"You wouldn't believe me if I told you."

* * *

A child's persistent sniffling annoyed a woman standing next to him. "Young man," she said, "have you got a handkerchief?"

"Yeah," replied the child, "but my mother won't let me loan it to nobody."

* * *

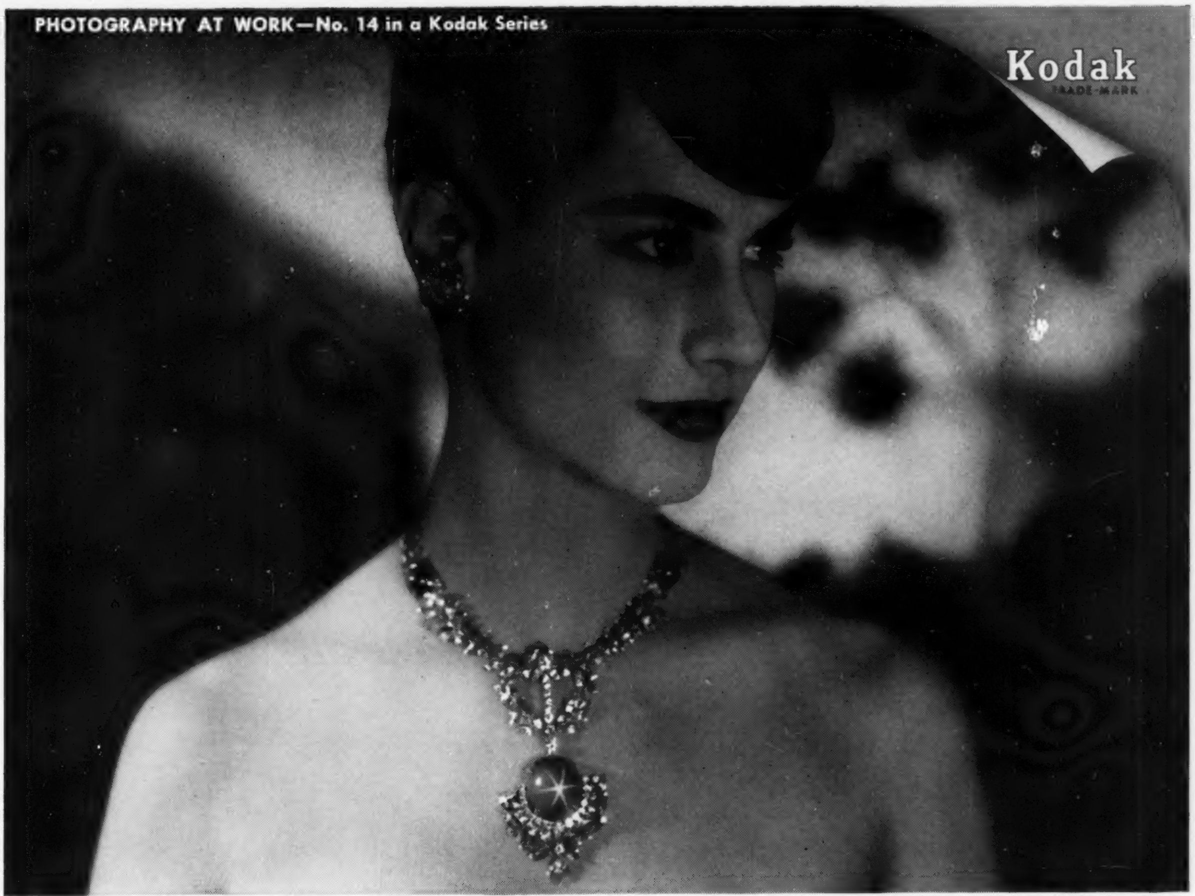
First co-ed: "I had to change my seat at the movie last night."

Second co-ed: "My goodness, did some fellow get fresh with you?"

First: "Finally!"

* * *

I wish I wuz a kangaroo
I wish I wuz a clock
I wish I wuz the orchid stripe
In sumwun's sky blue sock.
I wish I wuz a purple pigg.
With polkadotted trimming.
I wish I wuz a zooloo gal
I wish I wuz in swimming.
I wish I wuz a mutton legg
Or just a legg of lamm—
Ide gladdly be most ennything
But this dumm thing I amm!



Necklace of Linde Star Rubies and Diamonds worn at the Coronation of H. M. Queen Elizabeth II.

Man-made gems perfect as nature's finest—

created with the aid of photography's keen eye

Linde Air Products Company measures rare elements as close as 2 parts in a million with the spectrograph to produce star sapphires and star rubies more nearly perfect than natural gems.

Wartime instruments called for millions of synthetic jewel bearings. But supplies from Europe were shut off. So at Uncle Sam's request, Linde, a division of Union Carbide and Carbon Corporation, undertook to create sapphires and rubies—with photography filling a role in the intricate technology.

Postwar, Linde went even further. Using the spectrograph, a photographic instrument so sensitive it can measure the chemical content of celestial bodies, they found just the right trace of rare element to create a deep silky star within the stone and thus achieved the fabulous Linde "Stars"—man-made counterparts of one of nature's rarest gems.

This is the way photography is working in small companies and large, in laboratories, on production lines, in offices and drafting rooms. It is saving time, reducing error, cutting costs, improving production for all kinds of business and industry.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has created many challenging opportunities at Kodak, especially in the development of chemical processes and the design of precision mechanical-electronic equipment. If you are a recent graduate or a qualified returning serviceman, and are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Eastman Kodak Company, Rochester 4, N. Y.


WHERE PROGRESS IS UP TO YOU...
How will you help to sharpen radar's "eyes"?
Exact range and accuracy of the radar antennas shown here are classified. But this can be told—the radio energy transmitted can light fluorescent lamps 100 feet away.
Progress in radar, as in the entire field of electronics, has been rapid. At General Electric much credit for these advances belongs to engineers who are recent college graduates. Take, for example, E. B. Carrillo, EE, Pratt Institute, '49, responsible for manufacture of servo- and time-sharing systems, and G. G. Wilson, EE, N. Y. U., '48, in charge of design and development of remote control equipment.
The work of these young men typifies GE's emphasis on young, creative engineers from such fields as electrical, mechanical, metallurgical and aeronautical engineering, and from the scientific fields of physics and chemistry. Like other graduates, Carrillo and Wilson were able to increase their engineering awareness in the after-graduation G-E program of technical assignments. In this program, the engineer selects the fields, the locations himself. And at G.E. you will be able to make real contributions early in your career in activities ranging from plastics to large electrical apparatus, electronics to jet propulsion, automation components to atomic power.
For full information on the job at G.E. suited to you, consult your college placement director, or write General Electric Company, Engineering Personnel Section, 1 River Road, Schenectady 5, New York.
TR-2A
Progress Is Our Most Important Product
GENERAL ELECTRIC